LAND INFORMATION MANAGEMENT

Edited by

Ewan G Masters & John R Pollard

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PREFACE

This Land Information Management conference marks many years of involvement of the School of Surveying, University of New South Wales in the land information industry. It happens to also coincide with a visit by Professor John McLaughlin from the University of New Brunswick, Canada, to the School.

One aim of John McLaughlin's visit is to bring to a focus the problems in managing land and geographical information, especially in the context of what is happening in New South Wales. Most organisations realise the possible economic benefits of computerising existing information systems. However, many problems must be overcome before successful operational systems can be implemented. The comment is often made that Australia is a world leader in land information management. This conference aims to bring together a group of experts who have been involved with various aspects of the implementation and development of Land and Geographical Information Systems, to share their experiences and knowledge, and to advise on some of the developments in New South Wales, in other states and overseas. Many of the difficult problems in addressing the implementation and operation of these systems are not technological but management based. Papers are included on people issues, organisational issues, economic issues, legal issues and other issues vital to the implementation and maintenance of information systems.

Conferences of this type seem to be very rare in New South Wales. We believe that until now few people have had the opportunity to hear about the exciting developments that are occurring in the land information industry, both in this state and elsewhere. It therefore seems appropriate to take this somewhat unique and excellent opportunity, during the visit of John McLaughlin, to hold a conference on land information management. The conference unfortunately cannot hope to address every possible management issue. However, we believe that most of the important topics have been dealt with by the invited speakers.

It gives us great pleasure as editors of these proceedings to put together what we believe is a significant statement on land information management. We hope that these papers will continue to be useful and well used documents over the coming years and would like to thank the authors for their contributions to both the conference and these proceedings.

E.G.M.
J.R.P.
June 1991

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COORDINATE SYSTEMS FOR LIS

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ABSTRACT

An overall coordinate system is an essential component for a land information system, since it provides the spatial reference for information. Various approaches have been adopted to establish this spatial element. The paper discusses the issues involved in choosing coordinate systems and their application as a basis for spatial data management. Examples in Australia are used as illustrations.

A decision which must be made at the beginning is to choose which coordinate system to adopt. In those countries where integrated surveys exist, the system chosen for surveying is the obvious choice for the information system. Australian states and territories in general do not have truly integrated survey systems, though in all of them consideration has been given to how to introduce some form of integration. In nearly all cases, they have adopted the Australian Map Grid, or AMG, with zones 6^{o} wide, which is the Australian adaptation of the Universal Transverse Mercator. However New South Wales, taking into account the size of the projection corrections with the AMG, has adopted the Integrated Survey Grid with zones 3^{o} wide, for integrated surveys. The IGACSM has recommended the adoption of earth-centred coordinates all Australian States and Territories by the year 2000, but no opportunity has been given to the surveying and mapping industry to discuss the wide implications of this recommendation.

A further problem is the relationship between control surveys and parcel corners. In Australia, with the notable exception of the Australian Capital Territory, cadastral surveys are not precisely connected to the control network. When the coordinates of parcel corners have been required for use in LISs, the ACT, unlike others, has not been faced with a problem. In South Australia and New South Wales the depiction of cadastral boundaries on topographic maps has been digitized to form a DCDB, even though there are significant errors arising from the graphics and from other sources. In the ACT, because cadastral surveys are integrated with the control, the cadastral network forms one of the layers of information in the LIS. However in all other States and Territories, the approximate cadastral coordinates of the DCDB will be merely an auxiliary, until such time as the precision of the coordinates is eventually upgraded. Since this process will be on a piecemeal basis, it may take a long time.

INTRODUCTION

A land information system is, by definition, a *spatial* information system. The spatial information is carried by means of coordinates, which are used because they provide the most versatile and powerful means of expressing position. Thus the coordinate system is a vital and central component in an LIS.

The choice of a coordinate system is one of the fundamental decisions which must be made in establishing a land information system. If an integrated survey system already exists, then the obvious choice will be to adopt the coordinate system of those surveys. Such a choice minimizes costs and reduces implementation difficulties. If, however, cadastral surveys are not connected to coordinates and control, the choice is more flexible. In either case it must be realized that the system adopted will become the one used in future for a range of purposes, including cadastral and other surveys.

In the context of surveys and coordinate systems, the earth's surface is approximated by a sphere slightly flattened at the poles, called a reference ellipsoid. The coordinate system adopted can be latitudes and longitudes on this figure, or one of three projections of the ellipsoid onto a plane, the Stereographic, Lambert or Mercator projections. The dimensions of the ellipsoid have continually been improved, so that even adjacent countries may adopt ellipsoids with different dimensions. Positions, on these coordinate systems, are relative to the national geodetic network, and the relative positions of starting points of these networks could, until recently, only be determined approximately. The result is that, even though countries may share the same type of projection, each has a unique coordinate system, based on the adopted position of its own fundamental station.

In assessing a coordinate system, criteria of practical significance are that:

* the coordinates must be suitable as a spatial reference for all LIS applications, from the least to the most precise
* the system must be designed for ease of use, especially in everyday applications
* it must be cost-effective, and must make optimum use of the existing system to effect cost savings
* costs of conversion and improvement need to be taken into account in selecting the system
* the system must be stable over time - in practice this means that precautions should be taken to maintain the reference marks in good order.

In a parcel-based LIS, spatial units of the system are the parcels, defined by the network of parcel boundaries. The accuracy to which the coordinates represent cadastral boundaries and corners is important. It depends upon the existing survey system and, in turn, profoundly affects the establishment costs and the role of cadastral information in the system. The level of accuracy should reflect the value of the land now, and its expected future value. These factors will be discussed later in the paper.

PROJECTIONS

Although there are only three projections suitable for coordinate systems for surveying and LIS, in practice each country or state has its own unique system. There is no avoiding the differences, which arise because each country has its own reference system, based on its own origin, geodetic network and ellipsoid.

Geographical Coordinates

It is, in fact, not essential to adopt a projection for coordinates. Geographical coordinates - latitude and longitude - can be used. But there are two overwhelming disadvantages. First, geographical latitude and longitude are expressed in degrees, minutes and seconds, which combine numbers to base 60 and base 10. In computing terms, a single coordinate is treated as three numbers of differing length, with a single symbol for sign. For example, a position in Sydney is expressed as:

S 33° 52' 03.2884"; E 151° 12' 37.3769"

Data handling in an LIS involves the storage and processing of massive numbers of these coordinates. Geographical coordinates are therefore totally unsuitable for this application.

The second disadvantage is that the scale of each coordinate is different, with the latitude scale constant, but the longitude scale varying from 1.0 down to zero. This means that, whereas one second of latitude is the same amount, approximately 31 m, everywhere, one second of longitude varies from 31 m at the equator, down to zero at the poles. It is particularly awkward in higher latitudes, where the difference in scale is large and the change in scale over even a small latitude difference becomes significant. For example, in the latitude of Edinburgh, 56^{o},

Latitude scale: 1.0000 longitude scale: 0.5592

Twenty kilometres further north, longitude scale changes to 0.5566

Survey Projections

There are, therefore, overwhelming practical advantages in adopting a plane projection, and transforming the geographic coordinates onto the projection plane. Suitable projections are those in which the scale at any point is the same in all directions, that is, orthomorphic projections. There are basically three such projections, namely the Stereographic, Mercator and Lambert projections, corresponding respectively to plane, conical and cylindrical orthomorphic projections. These are termed survey projections. The choice of the most appropriate projection depends upon the shape and orientation of the region to be covered.

These projections are used with surveying measurements, which are generally very precise. In order to keep the projection in close correspondence with the ellipsoid surface which it represents, the projections are kept very narrow - up to a few degrees wide, only. Generally, for a territory which is narrow in the north-south direction and extends over a length east-west, the Lambert projection is suitable. For a narrow territory with north-south extent, the Transverse Mercator is most suitable. This is the Mercator projection with the basic cylinder shifted through 90^{o} so that it is tangential along a meridian, not along the equator. The projection extends in a strip from the equator, north and south along the meridian.

A territory which covers a range of longitude as well as latitude can be divided into a series of north-south strips, called zones, each covered by a narrow strip of Transverse Mercator projection. Each zone of the projection will be identical, with the same cylinder shifted round to a different meridian. There could be a temptation to subdivide the territory into east-west zones of latitude, each covered by a strip of Lambert conical projection. This is not as suitable, as each strip would have a different cone, tangential along a different latitude. In each strip, the geometry would differ, so each would be a distinct projection, not a repeat of the same projection, as in the Transverse Mercator case.

The normal Mercator projection is suitable only for the special case of a territory which extends east-west along the equator. The standard case of the Stereographic projection is tangential to the earth at the poles, where there is not a great need for a parcel-based LIS. The oblique case of the Stereographic, however, is suitable for a small territory which is roughly circular in shape, and in fact was chosen by the Canadian province of New Brunswick for its integrated surveys/land information system. However in this case the maximum difference between coordinates on the stereographic and on the more conventional Transverse Mercator amounts to a few millimetres at most.

Thus there are logical reasons for the choice of the Transverse Mercator as the standard projection in nearly all large territories. Specifically for mapping purposes, standard zones 6^{o} wide, covering the whole globe, have been adopted by international agreement, as the Universal Transverse Mercator (UTM) projection. "Universal" is misleading, since, as has already been mentioned, countries all have their own unique coordinate systems. Even though placed upon a "universal" projection, the same point on different national UTMs would have different positions. The Australian Map Grid (AMG) is the UTM applied on the Australian National Spheroid, and using positions from the national geodetic survey. The use of this projection is universal in Australia, for small scale mapping.

The systems chosen are in many cases related to the magnitude of the projection corrections, a topic which is taken up in the next section.

Examples of Projections Chosen

Examples of projections adopted for LIS are, in Australia, the New South Wales Integrated Survey Grid (ISG), established in the early 1970s for survey integration, which even at that time was recognized as a necessary preliminary for optimal computerization of the records. The zones were 3^{o} wide, to reduce the size of projection corrections. In the other States of Australia, however, the mapping system, the AMG with its 6^{o} zones has been adopted for LIS purposes (Angus-Leppan, 1976).

In the United States, where land is a State rather than a Federal matter, each State has adopted its own coordinate system. Roughly half are covered by Transverse Mercator and half by Lambert systems, and generally only a single zone is necessary to cover each State. This is clearly not the case for Texas, which spans over 13^{o} of longitude and 10^{o} of latitude, or for Alaska, spanning over 50^{o} of longitude and 20^{o} of latitude.

The world's largest country, the USSR, has 6 ^{o} zones for mapping at smaller scales, but has also adopted narrower, 3^{o} zones for large scale mapping, detail surveys and detailed resource planning.

New Zealand is an interesting case because, early in its development, a number of local plane systems, each with its own origin, were adopted as the basis for coordinating parcel boundaries. More recently, steps have been taken to supersede these with a national grid in a single zone, creating a system suitable for surveys of all kinds and for LIS. Because of its oblique orientation, an oblique projection has been adopted, which is analogous to an oblique Mercator projection. In practice, the projection is more complex, and is derived through a difficult, though mathematically very elegant, procedure.

Peninsular Malaysia is another territory which is oriented obliquely. Here, also, a projection of the oblique Mercator category was adopted. As this was in the days before electronic computers, special methods had to be devised to simplify calculations and projection corrections.

Thailand, in 1901, adopted local systems, each with its own origin, as the basis for cadastral surveys. Eventually the 73 Provinces were covered by 29 different local systems. No projection corrections were appplied, so the systems slipped into the category of a Cassini-Soldner projection, a non-orthomorphic projection (Angus-Leppan, 1989). Because the systems were all very small, the corrections would generally have been negligible.

Subsequent events were not so favourable. Traverses were run in all directions from the origins, with no overall control. Traverse loop was added to loop, and new traverses passed over older ones without connecting. By the 1980s, the surveyors involved were aware of multiple mistakes, which had become impossible to locate, and discrepancies in position of up to 80 m were found. In 1983, when the Land Titling Project was being planned, it was recommended, after careful study, that all the older control should be abandoned and a new start should be made with a system of well-controlled traverses, and a new projection, the UTM. Two of the 6^{o} UTM zones are required to cover the country.

Thailand's early experience provides an object lesson for regional administrations of land. It demonstrates, first, how a number of local systems can satisfy the need for control, with projection corrections minimized by keeping each system small. But, secondly, it highlights the chaos that results if a large number of ordinary surveys, of reasonably high precision, are all added together in chronological order.

The lessons are clear. In order to avoid the costly and disruptive process of starting again, it is essential to:

* establish orders of surveys, with higher order control surveys to form a precise framework, and lower order surveys, firmly based on the higher order and running between the members of the framework
* investigate gross errors as they arise, and if necessary repeat measurements, until all discrepancies are ironed out. Do not leave it to later measurements to define the position of the mistake.

Adoption of GDA2000, Geocentric Datum.

In Australia a recommendation has been made by the Inter-Government Advisory Committee on Surveying and Mapping (IGACSM, successor to the National Mapping Council), that all States and Territories should adopt an earth-centred coordinate system, GDA, by the year 2000. The justification for this change, and any of its advantages and disadvantages, have never been discussed generally within the surveying and mapping industry, and, besides the resolution itself, nothing has been published.

Since the advantages have not been presented, they have to be deduced by reasoning, in order to discuss them. They appear to be, first, that GDA is aligned to satellite systems, and is in tune with satellite positioning, which is the method of the future; and secondly that it provides an opportunity to set up a uniform coordinate system covering the whole of Australia.

The first advantage is illusory. On every occasion when point positions are determined from satellites, the results are produced from a very large adjustment. A computer of considerable power has to be available for this task, and for such a computer, the transformation of the final coordinates to another system, at the end of the adjustment, is a totally trivial matter, accomplished in microseconds or less.

A true geocentric system is oriented on axes which are defined astronomically, and has no fixed points on earth. The movements of the crustal plates, typically 5-10 cm per year, will cause changes of this size to all coordinates on a plate such as Australia. To avoid this problem, GDA will adopt the orientation at a particular epoch, relate this to Australia through the positions of fiducial points in the geodetic network, including satellite monitoring stations. Thus the orientation will be tied to the Australian crustal plate. However this removes the tie between GDA and the World Geodetic System (WGS) which is the system of the satellites. A transformation will be necessary between WGS and GDA, and the parameters will have to change with time, again by amounts depending on the crustal motion of Australia.

It is clear that the discrepancy between the WGS or satellite system, and Australia's system on its moving crustal plate, which is growing at the rate of about 10 centimetres per year, has to be accommodated somewhere in the processes. Analysis has shown that this drift makes it impracticable to use the coordinate system of the satellites. Moreover, it is irrelevant whether the system used is, like the GDA, close to (but not identical with) the satellite system, or requires a more elaborate transformation, like the AMG, since in all cases the transformation can be hadled by computer.

The second possible advantage is uniformity of coordinate systems, across Australia. Though this may have been important in the past, it is rapidly becoming less important; all significant data bases are being brought onto computer, where they can be processed - transformed if necessary - automatically and painlessly. By the year 2000, uniformity of systems will have become irrelevant.

There is only one proviso, albeit an important one. The values of transformation parameters between systems, and their changes with time, must be monitored and be made available in easily retrievable form.

Conclusion - Selection of Coordinate Systems

Reviewing the choice of projections selected for coordinate systems, it appears that the first criterion has been the ease and simplicity of the system in everyday use. This is a sound criterion, since it relates to time saved, and optimization in the economic sense. However there is another criterion which emerges in some cases, and this is a drive for uniformity, in the sense of using the same system for all purposes, as well as the same system in all territories. Although this criterion may work against ease and convenience in day-to-day working, its effect can be seen in the decision of Australian States other than NSW to adopt a mapping grid for purposes of integrated surveys, large scale planning and LIS.

In the modern context, data is always computer-based, and once a procedure, such as a transformation from one system to another, has been programmed into the computer, it can be reactivated instantly. So uniformity, which was highly desirable in the times before computers, has become less and less relevant. Since, with computers, data can be transformed with ease between different systems, the question for those choosing a coordinate system for a territory should be made on the basis of a comparing the economies of adopting a system which suits their own needs, versus the cost of transforming their own system for any wider regional applications which might arise.

PROJECTION CORRECTIONS

The plane surface of a projection cannot be made to fit exactly to the doubly curved ellipsoid surface, but it is possible to apply corrections to measurements on the earth to make them correspond to their equivalent on the projection. It is assumed below that the projection is the Transverse Mercator, though with only slight modifications, the description would apply to the other orthomorphic projections. For distances, these corrections are, first, the slope and "sea-level" corrections, to reduce measurements onto the surface of the ellipsoid, and, then, the projection scale factor. This remains very close to unity, provided the projection width is limited.

In angular measurement, the two projection corrections are the (t-T), which takes into account apparent bending, on the projection, of a straight sightline on earth, and meridian convergence, which accounts for the fact that, off the central meridian of the projection, the coordinate grid is not aligned to the meridians.

The correction of greatest practical significance is the scale correction, which increases as the square of the distance from the central meridian. This means that there are substantial advantages in keeping the zone widths narrow. In the countries of Central Europe and in South Africa, Transverse Mercator zones 2^{o} wide are used. The NSW ISG adopted zones 3^{o} wide, whereas the other States accepted the 6^{o} AMG, a mapping grid, in which the correction is far larger.

The contrast in the magnitude of the correction for 3^{o} and 6^{o} is shown in Figure 1, which also indicates how the meridian scale factor is applied in each case to reduce the average effect of the correction. The Figure shows that for a 3^{o} zone width, maximum scale correction amounts to 1 part in 4000 of the length, whereas for a 6^{o} it is four times as great, 1 in 1000. In each case the size of the correction is reduced, in practice, by the central scale factor, but maximum values still occur along the edges of the projection (Angus-Leppan, 1976).

COORDINATES AND CADASTRAL SURVEYS

In the Australian Capital Territory, from the time of initial development, cadastral surveys have been connected to precise survey control marks, so that the relationship between the coordinates and the cadastre is known, at the level of precision of the cadastral surveys. As a result, ACT surveyors have developed more efficient methods for subdivisions and other second generation surveys, making use of the precisely known coordinates of corners. Cost savings of 30% can be achieved using these methods. Availability of precise cadastral coordinates has also enabled the ACT Government to take steps towards the establishment of a fully coordinated cadastre, an initiative which will be described below.

The ACT is the only example in Australia of connected cadastral surveys, though in Central Europe, New Zealand, South Africa, Thailand or Malaysia, any other system would be unthinkable. In the Australian States, property surveys are unconnected and floating (though surveyors will state, with a straight face, that they are connected to adjacent parcels). Connecting to the coordinate control confers enormous advantages, because the coordinates provide an absolute position: the position of the surveyed parcel is related to every other survey on the system; positions of fixed corners are permanently recorded and can be replaced without repeating the investigation.

Prior to the establishment of ACTILIS, the ACT Integrated Land Information System, in the late 1980s, the basic information on parcel positions already existed in the form of precise coordinates of parcel corners. These coordinates, consistent to a few decimetres over the whole of the urban area, are sufficiently precise for all LIS purposes.

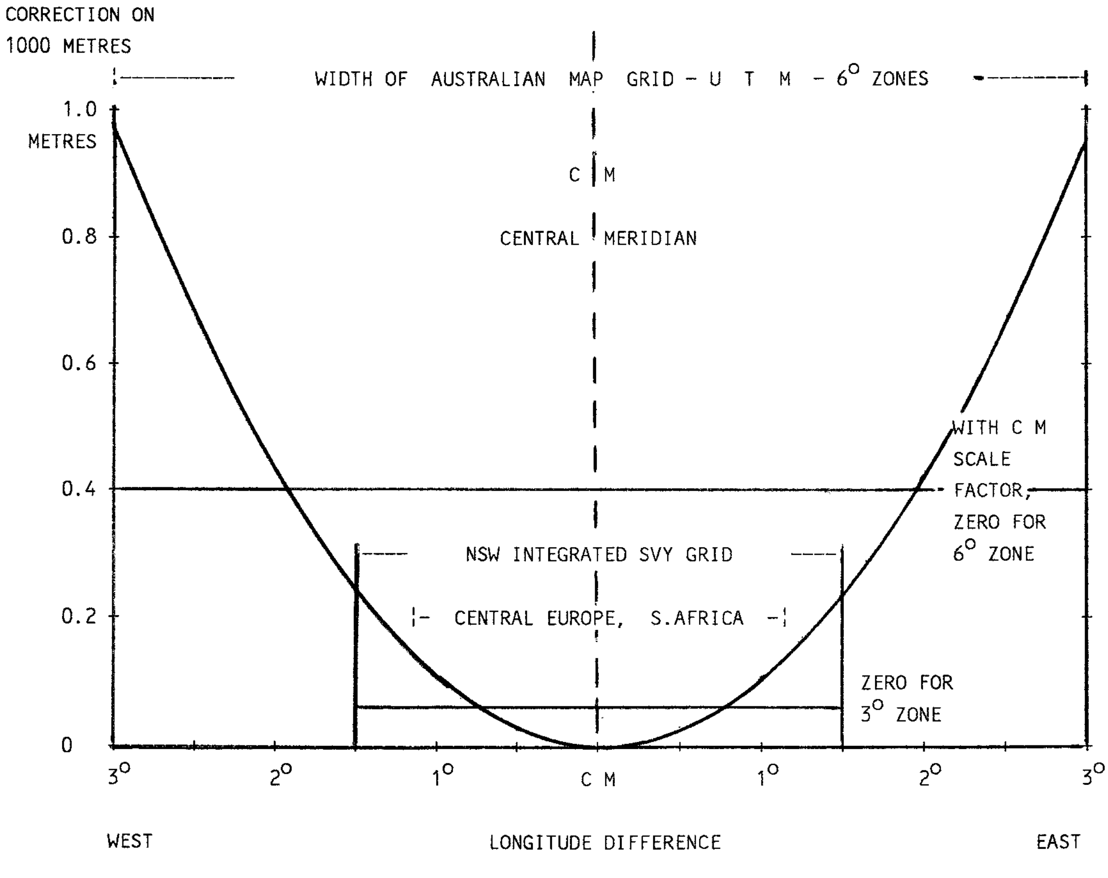

FIGURE 1 - PROJECTION SCALE CORRECTION

Variation with Distance from Central Meridian

South Australia - Case Study

In 1985, South Australia carried out a feasibility study into a coordinated cadastre (SA DOL, 1986). At that time, establishment of an LIS was well under way, but the survey control network was incomplete, and as a result was not extensively used. Although cadastral boundaries were generally not coordinated, work had already started on the Digital Coordinate Data Base (DCDB), and was due to be completed by 1988.

The South Australian experience is of particular interest because it allows an examination of their response to the need for parcel boundary coordinates for LIS, and also the method devised to update and improve the precision of those coordinates over time.

At the outset the feasibility study noted many fundamental deficiencies in the cadastral survey system, including the anomaly that though the "curtain principle" was applied for titles, survey redefinition required a full, time-consuming and costly historical search. Further problems were the system of isolated surveys, the related methods of survey and assessment of precision, and the lack of a complete system of control surveys; the examination process for surveys was costly and caused delays. The existing cadastral survey system was found to be unsuitable for SA's parcel-based LIS (SA DOL, 1986, 29-31).

To derive parcel coordinates, the DCDB used the most accurate maps available. This implies a graphical accuracy, and though there may be more sophisticated measures, a good approximation is that the precision will be 0.5 mm at map scale: 0.5 m on a 1/1000 map, 2 m on 1/4000 and 25 m on 1/50,000. This assumes that the plotting of the cadastral boundaries is free of errors, so the figures are minimum values.

After studying a range of options and holding a seminar/workshop for surveyors, the solution recommended was to gradually update coordinates in the DCDB as new surveys based on the control system became available; to improve DCDB coordinates using reliable historical parcel data; and to establish Designated Survey Areas, where the density of survey control was adequate, and where it would be compulsory to connect all new surveys to control. Current levels of expenditure were to be maintained. The development of GPS was to be monitored for possible use in accelerating the completion of survey control, and the future adoption of a legal parcel coordinates was to be studied.

Parcel Coordinates in New South Wales

New South Wales faced a situation similar to that in South Australia, and the solution was also similar. The Department of Lands had worked on the problem of positioning cadastral boundaries, for topographic mapping purposes for decades, and various methods were attempted. One was to run "traverses" using cadastral boundary information, between control points. Computer adjustment of the network of boundaries was also attempted, but identification of m ultiple gross errors was a serious difficulty. Another method was to plot fence lines, which were visible on large scale orthophoto maps, and correlate plotted positions with boundaries. As a result of these efforts, all major cadastral boundaries had been plotted onto the topographic maps with a fair degree of reliability, before the information was required for LIS purposes.

In 1990 a cost benefit study into the establishment of a digital mapping database was undertaken, by a firm of consultants, for the NSW Land Information Centre. The study looked in particular at the costs and benefits of digitizing the State's cadastral and topographic data. The results were not published, but it is known that they favoured the accelerated digitization of the data, making use of the resources of the private sector to carry out the actual digitization. The option investigated was to complete the digitization for the DCDB by 1994 and the DTDB (Digital Topographic Data Base) by 1997.

As in South Australia, the precision of the DCDB is graphical: it cannot be better than the precision yielded by the topographic map used for digitization. As an indication, for urban areas the scale is 1/4000 and the error approximately 2 m; in rural areas in the eastern sector of the State, 1/25,000 mapping is the rule, with errors of 12.5 m; in the central sector, 1/50,000, with 25 m errors, and in the western zone 1/100,000 with 50 m errors. This assumes that there have been no errors in compiling the cadastral network - it will not always be the case, so the additional effect of any such errors must be added. One of the problems in digitization for the DCDB is that a significant portion of the cadastral mapping is up to 15 years out of date.

NSW, like SA, intends to establish Designated Survey Areas, where connection to survey control is compulsory, and to improve the DCDB coordinate values on the basis of new surveys which are connected to survey control. However in the NSW case, the details and methods have not been specified.

ACT CADASTRAL COORDINATE SYSTEM

From the time of first development, surveys in the ACT have been based on a coordinate system, and precise coordinates of all cadastral corners have been known. In contrast to South Australia and New South Wales, where establishment of a DCDB for LIS was a large and expensive task, in the ACT the DCDB was available in a form suitable for use in an LIS, when the time came for the establishment of a land information system. Recently, the ACT Government has been examining ways to adapt its cadastral system to take full advantage of new technology. This has led to a proposal to enhance the role of coordinates and ultimately to use them to legally define the positions of property corners.

In 1989 a review by T.M. Johnstone and K.N. Toms, legal and cadastral experts, respectively, recommended the adoption of a legal coordinate cadastre (Johnstone & Toms, 1989). Before taking this step, the ACT Government commissioned a study of the costs and benefits involved in establishing a coordinated cadastre. The study was undertaken by the authors of the present paper (Angus-Leppans, 1990).

In fact, the ACT has three coordinate systems covering different areas: they evolved at different times, were defined differently and minor inconsistencies can be detected. Positions in the oldest, the CC zone (City Coordinate zone), have shifted with time, and most control marks have been lost. The other zones, the PGC and AGC are inconsistent by up to 0.20 m. The aim is in due course to adopt a legal cadastre, and for this purpose the greatest discrepancy should be limited to 2-3 centimetres (See Figure 2).

The cost benefit study analyzed several options, to adopt a new system (AMG, ISG or earth-centred), to adopt the most precise of the existing coordinate systems or to adopt the three zones, each in its own area. the recommendation was to adopt the AGC coordinates (Adjusted Grid Coordinates), and convert positions in the other zones to the AGC. In the CC zone, the recommendation was to extend new AGC control, and to resurvey the parcels as required, updating the DCDB coordinates as this occurred.

A further recommendation was that when an area meets the two requirements that the survey control is sufficiently dense, and the cadastral corners are satisfactorily coordinated, it will be declared a Proclaimed Survey Area. In such areas, it is compulsory to base surveys on the control, as in SA and NSW. In addition, however, based on new legislation which will upgrade the status of coordinates as evidence, coordinates will define the positions of cadastral corner points. The ground point will be the physical indication of that coordinate position.

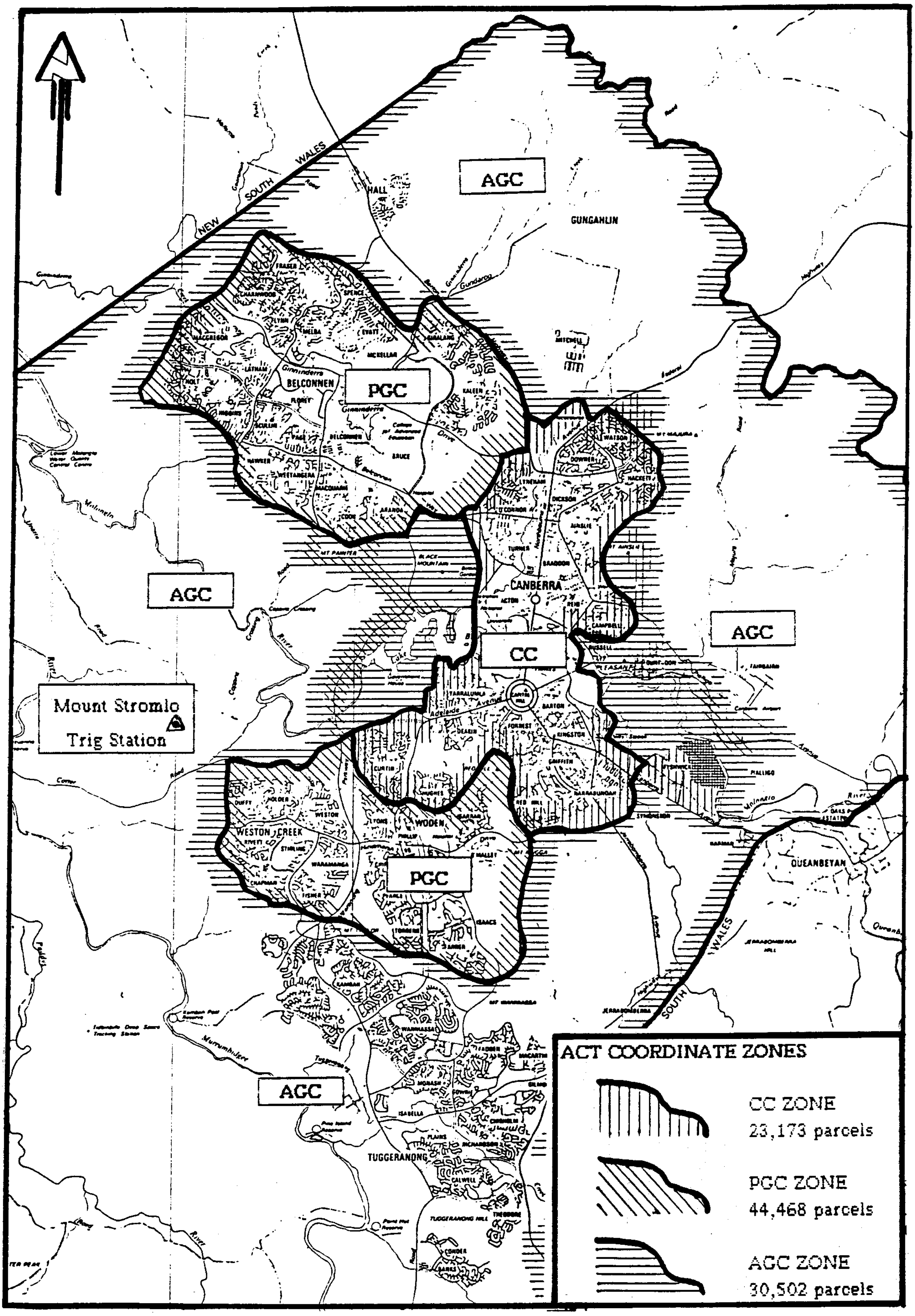

FIGURE 2 — ACT COORDINATE ZONES

Details of the cost benefit evaluation are as follows:

* For each of the coordinate systems, the cost of upgrading the control network is the same, approximately $A 3.5 million for the 100,000 parcels in urban ACT. Large differences however, are associated with the cost of recalculating / data-basing all parcels not currently on the proposed coordinate system. This results in overall costs of $A7.7 m. to implement a new (AMG, ISG or GDA) system, $A 6.4 m. to adopt AGC control throughout the ACT and $4.5 m. to adopt a system retaining the three existing sets of coordinates. Applying these costings to other systems, the findings indicate clearly the cost advantages of using an existing survey system, if a suitable one is already in use.

* However, even to maintain the quality of the system as it currently exists would require expenditures of a minimum of $A 2.3 million, so that the marginal cost of adopting each proposed system should be reduced by this amount.

* Because the ACT already enjoys very substantial benefits due to the existing high quality system, the additional direct benefits (in terms of cost savings on surveys) associated with each of the proposed coordinate systems, are similar, and relatively small (discounted value of approximately $ A 300,000 over the first 10 years). However in other circumstances, when a system is upgraded from a lower level, very substantial benefits, in money terms, will accrue. Over the full useful life of the coordinate system proposed for the ACT, the survey benefits should approximately cover the marginal cost of adopting the proposed AGC system, but not that of a new system such as the AMG.

Additional features that will be incorporated into the ACT system will be:

* the "curtain principle" for surveys as well as titles. This means that no further information will be necessary for a resurvey, apart from what is shown in the DCDB.
* "continuous DP". In some jurisdictions, parcel details are recorded on a cadastral plan showing all parcels, rather than on plans of single parcels. The continuous DP is a computerized form of the cadastral plan, which, because it is computerized, has the advantage of not having map sheet edges.
* Legal Coordinated Cadastre. It is the aim of the ACT Government to establish a legal coordinated cadastre, in which the coordinates of a cadastral corner are not only given greater priority, but legally define the point. Under this system, it will be feasible to guarantee the position of the corner, within a defined precision.

THE ROLE OF CADASTRAL COORDINATES

In the relationship between survey control and cadastral boundaries, there is a marked contrast between the cases of SA and NSW on the one hand, and the ACT on the other. In the two States, the precision of position for parcel corners in the DCDB is limited by the scale of the topographic mapping from which they were digitized, and in addition there are strong possibilities that the processes of determining the graphical coordinates have introduced some gross errors. These coordinates suffice for the requirements of the LIS, but are of no use in the cadastre. Cadastral surveys in Australia need a precision of centimetres, not metres. In the ACT, in contrast, the precision of the cadastral coordinates is exactly the same as the precision of the actual parcel surveys.

In the ACT, because cadastral surveys are integrated with the control and the precision of the parcel survey and the coordinates are identical, the cadastral network forms one of the layers of information in the LIS. Cadastral information is in fact an important component in the LIS, a distinct layer of information, and a firm basis for position in all levels of information. The addition of a further level of information is significant because of a combination of two advantages: the inherent importance of position in LIS, and the factor that the essence of value in LIS stems from the multiple relationships between different levels of data.

In contrast, in SA and NSW, the cadastral positions are known to a precision which is generally just sufficient for referencing other LIS information. The information is auxiliary, required for the working of the system, but not a subject of the LIS like the other layers of information. It is intended, in SA and NSW as in other States, to gradually upgrade the precision of cadastral information, as surveys are undertaken. But ther will be no systematic coverage, district by district, so it is likely to take as long for this upgrade as it has taken for "old system" titles to be superseded - over 100 years.

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DIGITAL DATA FOR LAND/GEOGRAPHIC INFORMATION SYSTEMS: OFF-THE-SHELF OR DO-IT-YOURSELF?

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ABSTRACT

The proliferation of land/geographic information systems (LIS/GIS) has led to ever increasing demands for digital spatial data. This demand encompasses both vector and remote sensing raster data, including integrated data sets.

Many LIS/GIS bureau services and users have elected to capture their own data by digitising or scanning base maps. In many cases, this practice is illegal as it is in breach of copyright.

The majority of digital data and base maps are owned by government agencies. Many of these agencies have been directed by their respective governments to rationalise their provision of services to increase their effectiveness and efficiency. This includes operating on cost recovery or commercial lines.

The Australian Surveying and Land Information Group (AUSLIG) is a major producer of national digital data sets. These data sets include both vector and raster. Vector data sets include topographic, administrative boundaries and resource/ environmental. Raster data includes Landsat and SPOT. AUSLIG also produces digital elevation model (DEM) data.

This paper considers the major options and related issues concerning the acquisition of spatial data for LIS/GIS, viz. obtaining data from a supplier or capturing your own data. AUSLIG's range of data products are presented as an example of the "off-the-shelf" option.

INTRODUCTION

Arguably, data are the most important component of any land/geographic information system (LIS/GIS). For many users there is a lack of understanding about data, especially concerning issues such as costs, copyright and ownership, quality and structuring. Off-the-shelf or Do-it-yourself? The choice of spatial data for a LIS/GIS, is it really that simple?

The majority of spatial data covering Australia are owned by government agencies. At the federal level, the Australian Surveying and Land Information Group (AUSLIG) is the Commonwealth Government's major producer and custodian of spatial data. Like many government service agencies, AUSLIG is required to charge for the services it provides, including the licensing of spatial data to users. Furthermore, AUSLIG is responsible for administering the Commonwealth's ownership of these spatial data.

Many of the digital spatial data available to users, particularly small and medium scale data, are mainly suited to mapping applications, rather than LIS/GIS. Many of these data sets are poorly structured and are featured-coded rather than attribute based.

The application of LIS/GIS and remote sensing technologies to planning, land and resource management, mapping, environmental impact assessment and to many other land-related applications is now well recognised. Better integration of these technologies is seen to offer more powerful tools for users. For example, the ability of high resolution satellite imagery data to provide the "current information" layer in a LIS/GIS is now possible.

OFF-THE-SHELF - AUSLIG DIGITAL SPATIAL DATA

General

AUSLIG supplies two generic spatial data products:

- data derived from AUSLIG's small and medium mapping scale activities (AUSMAP Data)
- satellite data received and processed by the Australian Centre for Remote Sensing (ACRES).

In addition to the "off-the-shelf" AUSMAP Data and ACRES product ranges, AUSLIG will also produce "customised" products on client request. These "customised" products may include:

- integrated AUSMAP Data/ACRES data sets
- integration of AUSLIG and or ACRES data with other data.

AUSLIG is conscious of the limitations of some of its digital mapping data, which in many cases are only suitable for "backdrops" to other data sets. Data issues such as data quality, data structuring, import into LIS/GIS and more efficient and reliable data transfer are being addressed through the development of the Australian Geographic Data Base (AGDB). Data production for the AGDB is scheduled to commence during early 1992. Details of the AGDB are provided in Appendix C.

AUSMAP Data

AUSLIG is a major producer of digital spatial data. The majority of these data have been by-products from AUSLIG's national mapping programs. These data have the generic product name, AUSMAP Data.

The AUSMAP Data product range does not include large scale data sets acquired as a result of any of AUSLIG's cadastral, engineering or topographic client-based activities, nor digital remote sensing satellite data from ACRES.

AUSMAP Data products cover the following range of themes:

- topography (including digital elevation models and place names)
- administrative boundaries
- resources and environment.

With the exception of digital elevation models, place names and a few other data sets, the AUSMAP Data product range is vector-based. Appendix A lists the current range of "off-the-shelf" AUSMAP Data products.

In addition, AUSLIG has an arrangement with the Australian Army's Royal Australian Survey Corps (RASvy), to distribute their data on request to clients. These data are primarily topographic data at the scales 1:50 000, 1:100 000 and 1:250 000.

In 1990, AUSLIG introduced a system of data quality standards comprising 5 levels, as follows:

- Level 0 First capture, map production data. Data at this level have not been edited to ensure consistent data quality and are unstructured.
- Level 1 Basic map production data. Data at this level have been edited and have simple attributes assigned.
- Level 2 Level 1 data with explicit topology.
- Level 2.5 Level 2 data with additional attributes.
- Level 3 Level 2.5 data where the topology is further enhanced.

AUSLIG ceased production of Level 0 data in 1990.

Remote Sensing Data

The Australian Centre for Remote Sensing (ACRES) is a business unit within AUSLIG. ACRES is the only reception site in Australia for high resolution satellite imagery suitable for use in LIS/GIS. Currently, ACRES has the capability to receive and process:

- Landsat-5 Thematic Mapper (TM)
- SPOT (System Probatoire d'Observation de la Terre) High Resolution Visible (HRV) multi-spectral (XS) and panchromatic (PA)
- NOAA (US National Oceanic and Atmospheric Research Administration) Advanced Very High Resolution Radiometer (AVHRR) data.

ACRES is also able to receive data from the Japanese MOS 1 Satellite (Marine Observation Satellite).

ACRES is currently being upgraded to receive and process data from the ERS 1 satellite due to be launched in 1991. This satellite will have an operational synthetic radar sensor able to image through cloud and at night.

Appendix B provides a summary of satellites accessed by ACRES.

The data from these satellites are distributed by AUSLIG, Canberra, and also through a network of licensed distributors throughout Australia. The data sets available include photographic products and digital products. The imagery is in raster format and can be purchased at a range of scales and scene sizes and at several levels of geometric and radiometric corrections.

ACRES provides three levels of satellite data products:

- bulk corrected data - Data which have been processed to remove sensor, platform and scene related errors along the scan line
- georeferenced data - Data which have been corrected by removing the geometric errors and then transformed to a map projection
- geocoded data - Georeferenced data which have been rotated to align the scan lines with the map projection grid and resampled to a standard rectangular pixel size.

In the application of remotely sensed data in LIS/GIS, the choice of spectral bands is important, as different features are detected in different regions of the electromagnetic spectrum. The types of digital enhancements offered by ACRES are:

- directional filters to enhance linear/boundary features
- ratios, where different bands are mathematically considered to enhance areal features like vegetation and water bodies
- merged data, where both high spatial and spectral resolution is achieved through a mathematical transformation, e.g. merging SPOT panchromatic with TM data to provide 1 to 6 spectral bands of 10m resolution data.

COPYRIGHT OF AUSLIG SPATIAL DATA PRODUCTS

General

The copyright and intellectual property rights of AUSLIG spatial data and graphic mapping products fall into two categories:
- Commonwealth ownership
- satellite operator ownership.

Commonwealth

All AUSMAP and AUSMAP Data products are owned by the Commonwealth of Australia. These products include digital data, maps, atlases and graphics. This ownership includes copyright and all intellectual property rights of these products.

Within the Commonwealth, AUSLIG is the custodian of all AUSMAP Data products and other AUSLIG created digital data. Such custodianship includes the right of AUSLIG to charge for the access to and use of AUSMAP Data products. AUSLIG's custodianship was confirmed by the Cabinet of the Commonwealth Government in its decision in September 1988.

Within the Commonwealth, AUSLIG's custodianship can be considered to be equivalent to ownership. Cabinet determined that AUSLIG's custodianship covers all data created by AUSLIG, regardless of the purpose for which the data were created. This custodianship includes products derived or enhanced by AUSLIG, where that enhancement has been substantial, even where the data includes (by permission) the original data of other custodians.

Cabinet's decision also confirmed AUSLIG's responsibilities as the Commonwealth's primary source of advice and information on geodesy, surveying and mapping (excluding Defence mapping), coordination of land information, and on the general policy and procedures related to access, storage and dissemination of spatial data.

AUSLIG supplies data to its clients under licence. Two principle forms of licence are used by AUSLIG:
- Standard Licence
- Non-Standard or Distributor's Licence.

The Standard Licence is a non-exclusive, non-transferable licence to access and use AUSMAP Data by a licensee for a licensee's own internal purposes. It is not issued where the licensee will distribute the data to third parties and or produce products from the data which will be sold, given away or otherwise traded.

AUSLIG proposes to introduce three levels of Standard Licence as from 1 July 1991. The level will depend on the licensee's level of access to and use of the data. AUSLIG proposes three levels of access for the Standard Licence:
- Single
- Site
- Corporate.

A "Single Access" licence entitles the licensee to be able to access and use the data supplied via one point of access (POA). A POA includes a personal computer, a single terminal on a network, the keyboard/screen of a workstation etc. The licensee pays a standard (single) fee for a single licence.

A "Site Access" Licence entitles the licensee to two to nine POA (inclusive). The fee for the "Site Access" Licence is two times the standard fee (i.e. twice the fee for a "Single Access" Licence).

A "Corporate Access" Licence entitles the licensee to ten or more POA. The licence fee is three times the standard fee.

The Distributor's Licence is a non-exclusive, non-transferable licence to access and use AUSMAP Data for purposes which may include selling, giving away or otherwise trading AUSMAP Data or any product derived from AUSMAP Data. The conditions of the Distributor's Licence are determined on a case by case basis. Generally, AUSLIG requires payment of a licence fee and royalties. It is AUSLIG policy not to grant an exclusive Distributor's Licence to any licensee.

In some circumstances, AUSLIG may make available reproduction material (Repromat) to clients for the purposes of digitising or scanning when AUSLIG cannot provide digital data. This may be subject to the payment of a fee to AUSLIG and provision of a copy of the digital data to AUSLIG. Also, the data must be captured to AUSLIG specifications. Any digital data captured in this manner is Commonwealth copyright and subject to the usual licensing conditions administered by AUSLIG.

Satellite Operators

ACRES routinely receives data from a range of satellites that overpass Australia. These data are received and distributed throughout Australia by AUSLIG under special licence agreements with the satellite operators which maintain the copyright in the data. Therefore, the Commonwealth does not own the copyright of these data. AUSLIG's custodianship role in these data is one of providing an archive of data that Australian users can access. The conditions of use for the data are set by the licence agreements with the satellite owner.

The respective agreements between AUSLIG and the satellite owners are designed to protect the commercial interests of the satellite owners by prohibiting free exchange of data. The provisions vary slightly between LANDSAT and SPOT. However, in each case, a purchaser of imagery from ACRES or a distributor, is required to sign a "conditions of sale" agreement which places restrictions on the use of the data to within the company or agency purchasing the data. Within Australia, ACRES has a monopoly on high resolution earth resources satellite data acquisition. Distribution of these data occur through ACRES and its distribution network.

There are considerable differences in the copyright provisions for "enhanced" or "value-added" products derived from satellite imagery data when compared to products derived from AUSLIG's AUSMAP Data or other AUSMAP products. If "irreversible" enhancements are made to produce value-added products from satellite data, then these products are then free of the original copyright provisions. Note that this principle of "irreversible enhancement" is not applicable to AUSMAP Data and other AUSLIG products which are protected by Commonwealth copyright.

DO-IT-YOURSELF DATA FOR LIS/GIS

Considerations

In terms of acquiring spatial data, the user has a number of choices. These include:

- purchase of a data licence from a data supplier
- data capture by the user
- combination of the above.

Considerations for the spatial data user in making this choice may include:

- project requirements
- the user's available resources (human, hardware, software)
- external resources and expertise available (e.g. bureau services)
- the user's expertise
- cost
- priorities and deadlines
- availability of existing data
- suitability of existing data
- legal aspects of using existing data or source materials
- data integration issues.

Data Capture Methods

Methods of capturing spatial data include:

- ground/field survey
- digitising existing graphics
  - . manual/table digitising
    - blind
    - interactive
  - . semi-automatic (e.g. line following device with human interface
  - . automatic or raster scanning
- photogrammetric
  - . manual
  - . stereo-digitising
- imagery
  - . airborne platform
  - . space platform
- any combination of the above.

DATA COSTS

The costs of the data component in the development of any LIS/GIS project are frequently overlooked. These costs cover collection, capture, processing, integration, maintenance, quality control, security etc. Granger (1990) comments that data costs can make up as much as 90% of the total investment in a LIS/GIS.

One of the realisations of cost recovery in the provision of services by Government is that users are required to pay significant fees to obtain spatial data, which were previously supplied either freely or at nominal rates.

AUSLIG was among the first Commonwealth Government agencies directed to move to cost-recovery. For AUSLIG, cost recovery is handled in two ways:

- commercial activities which are client-based are on full cost recovery
- community service obligations (CSO) or public interest have been set a revenue target currently equivalent to about 20% of costs across the entire program of CSO activities.

CSO activities include national mapping (includes AUSMAP Data), operation of ACRES, national and Commonwealth coordination of land information, and geodesy. Revenue received is re-invested in these important programs.

AUSLIG's current fees for digital data do not represent the real costs that have been incurred in acquiring the national mapping bases. The real costs amount to hundreds of millions of dollars. For example, AUSLIG currently charges $400 for the culture, relief and drainage layers for a 1:250 000 or 1:100 000 map sheet. For one layer, the fee is $200.

Similarly, the investment in ACRES facilities and ongoing operating costs, are in the order of millions of dollars. In addition, satellite access fees cost hundreds of thousands of dollars per annum.

To further illustrate data costs, consider the costs involved in digitising a 1:100 000 topographic map sheet. For any such sheet, the level of content and complexity of information on the map is an important consideration as to whether the data will be captured by table digitising or scanning. Features such as railways, powerlines, pipelines and all point features are usually table digitised by AUSLIG because the symbolisation and density of these features on any sheet often do not lend themselves to efficient scanning.

The direct cost in scan digitising the drainage, relief and culture layers of a 1:100 000 topographic map is on average $1,000 per layer. For complex layers, the cost could be much higher, perhaps as much as $15,000.

The bottom-line for spatial data users is that they must contribute to the cost. Whether the user is from the private sector, the Commonwealth, State or Local government, the user-pays principle applies. Many users find it incongruous that their data costs may be far in excess of their LIS/GIS hardware and software costs.

CONCLUSION

The land/geographic industry has witnessed dramatic decreases in the costs of hardware and software, during the last five years. During this period, the industry has also witnessed dramatic increases in fees for spatial data, particularly as government agencies have adopted cost-recovery practices. The education of spatial data users about the real costs of data still has a long way to go.

For many users, spatial data issues such as structure, quality, transfer procedures etc. may not be of interest. Many of these users have limited (or zero) knowledge or expertise in spatial data. Often they require "turn-key" solutions that only require of them basic skills to operate their computer to enable them to carry out routine enquiries.

The industry has also seen the emergence of an increasing number of data brokers and value-added retailers seeking a piece of what is still a relatively immature market. These "data intermediaries" may provide an attractive alternative for users who lack expertise and knowledge in the data component of LIS/GIS.

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APPENDIX A

CURRENT AUSMAP DATA PRODUCTS

The following is a summary of existing (and proposed) AUSMAP data products:

	Description	Capture Scale	Level Available	Transfer Format
TOPOGRAPHIC				
1.	Baseline and Bay Closure Lines	1:100k	1	AS2482
2.	Coastline	1:100k	1	AS2482
3.	DEM - Critical Aeronautical Heights	NA	ST	Formatted ASCII
4.	DEM - Spot Heights	NA	SPF	AS2482
5.	DEM - 18" Grid	NA	SPF	AUSLIG DEM format
6.	Master Names File	1:100k,1:250k	ST	Formatted ASCII
7.	Topographic Base	1:100k	0,1,2	AS2482, GINA
8.	Topographic Base	1:250k	0,1,2	AS2482, GINA
9.	Topographic Base	1:1m	0,1	AS2482, GINA, ARC/INFO
10.	Topographic Base	1:2.5m	0, 2.5	AS2482, GINA
11.	Topographic Base	1:10m	0,2	AS2482, GINA
ADMINISTRATION				
12.	ARWC Representative Drainage Basins	1:250k	2	GINA, ARC/INFO
13.	Census Boundaries 1986	Various	2	AUSLIG Census Format
14.	Commonwealth Electoral Boundaries	Various	2	GINA
15.	Legal Local Government Areas	Various	2	GINA
16.	National Estate Areas	Various	2	GINA
17.	Public Lands (Land Tenure)	1:250k	2.5	GINA
18.	ATSIC Boundaries	1:5m	2	GINA
RESOURCES AND ENVIRONMENTAL				
19.	Dams and Storages	NA	2.5	GINA
20.	Minerals	1:2.5m	2.5	GINA
21.	Vegetation - Natural	1:5m	2.5	GINA, ARC/INFO
22.	Vegetation -Present	1:5m	2.5	GINA,ARC/INFO

Notes:

ST = Structured Text Records NA = Not Applicable

SPF = Single Point Features AWRC = Australian Water Resources Commission

APPENDIX B

SATELLITES CURRENTLY ACCESSED BY ACRES

Satellite/sensor	Channels	Pixel Size (m)	Swath Width (m)	Repeat Cycle
NOAA/AVHRR	5	1100	2400	4 per day
Landsat/MSS	4	80	185	1 per 16 days
Landsat/TM	7	30	185	1 per 16 days
SPOT/HRV				
XS	3	20	60x2	1 per 26 days plus off nadir request
PA	1	10	60x2	as above
MOS-1/MESSR	4	50	100x2	1 per 17 days
ERS-1	C band	30	5	1 per 3 days

APPENDIX C

AUSTRALIAN GEOGRAPHIC DATA BASE

Most of the spatial digital data sets (excluding ACRES) available from AUSLIG are primarily suitable for mapping purposes rather than LIS/GIS applications. Notable exceptions include the 1986 Census data set, Land Tenure, Vegetation and recently captured topographic data.

AUSLIG is conscious of the limitations of much of its current digital mapping data. In many cases, these data are only suitable for "backdrops" to other data sets. Often, LIS/GIS users may be required to spend considerable time "cleaning" and re-structuring data which have been supplied to them. "Cleaning" may involve:

- eliminating overshoots, undershoots, gaps and other data errors such as artifacts
- ensuring polygon closure
- checking that all polygons have centroids
- inclusion of nodes at arc intersections
- introducing other topological information.

Furthermore, many of the data being supplied to users are not accompanied by adequate documentation.

AUSLIG is addressing issues concerning data quality, data structuring, import into LIS/GIS and more efficient and reliable data transfer through the development of the Australian Geographic Data Base (AGDB). The AGDB will be a digital database comprising coverages derived from AUSLIG's mapping data. These coverages will include the themes:

- hydrography
- relief/hyposography
- transport and communications
- boundaries
- resources and environment.

AGDB data will be topologically structured and attributed and will be suitable for LIS/GIS applications.

Implementation of the AGDB represents a new direction for AUSLIG. The digital data becomes the primary product rather than the map.

Currently, as the first phase of AGDB development, the product specifications for the AGDB are being defined. The product specifications will provide the frameworks for defining the specifications for the capture of all AUSLIG digital data. All validation procedures, user documentation, archive and transfer formats will be derived from the AGDB product specifications.

The initial emphasis of the AGDB development will be with vector data, viz. 1:250 000 topographic data. Eventually all AUSLIG vector data will form the AGDB.

The proposed AGDB data model will be based on the concept of a feature-based spatial data model. Such data models are being used or implemented by the US Geological Survey (USGS), US Bureau of Census, the British Ordnance Survey and a number of European nations (Guptil *et al*, 1990).

Because not all users will require the same level of topological structuring or attribute detail, there will be three levels of AGDB data, as follows:

- AGD-1 - feature coded, clean data
- AGD-2 - clean data with attributes and an explicit topological structure and attributes
- AGD-E - will contain all the characteristics of AGD-2 data, but with additional characteristics (e.g. additional attributes, multi-feature coding) which will be supplied at a premium when requested by the user.

Once the product specifications have been finalised, AUSLIG will develop consistent specifications for production, quality assurance, archive management and data transfer. Obviously, at this point in time, AUSLIG does not hold data conforming to the proposed AGDB data model structure. AUSLIG will begin producing these data and supplying data to users once these specifications have been finalised. Production is due to commence in early 1992. It is anticipated that existing AUSLIG spatial data will be brought up to AGDB standards over the longer term.

AUSLIG recognises that not all users require topologically structured data. This may be due to the basic cartographic uses of the data. In the medium term AUSLIG will continue to provide data to clients in AS2482 format, the existing Australian Standard for interchange of feature-coded data (Standards Australia, 1989). However, clients may be required to pay a premium for such non-AGDB quality data.

As the new Australian standard for the transfer of spatial data is yet to be finalised, AUSLIG plans to provide AGDB data in the vendor formats currently used in-house by AUSLIG, viz. GINA (GeoVision AMS) and ARC/INFO (Export format from the GIS vendor ESRI). The current thinking is that the Australian standard will be a clone of the U.S. Spatial Data Transfer Standard (SDTS). In anticipation of this, AUSLIG is undertaking development of profiles of the SDTS for archive and transfer of AGDB datasets.

AUSLIG proposes to export AGD-2 data as the standard product.

Additional characteristics proposed for AGD-E will not be captured in the standard production process. These extras will only be captured on request from clients, on a user-pays basis.

As the needs of AUSLIG's clients become more sophisticated, it may become necessary to define a new quality level that may become the standard level for export to users. This level may encompass some or all of the optional characteristics proposed for AGD-E.

At this stage, AUSLIG is not addressing the inclusion of non-vector data in the AGDB. Such data includes Master Names File, DEM and of course ACRES remote sensing data.

Synthesizing Semantic Data Models and Structured Process Descriptions for Spatial Information Systems Design.

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ABSTRACT

This paper begins by describing a generally accepted view of the contemporary information systems development process. This process assumes the direct derivation of a prototype from data models which have themselves been derived from a functionally decomposed representation of reality. The data models are constructed using entity-relationship modelling (ERM) and data flow diagramming (DFD) techniques.

Next the paper considers the use of Petri net representations as *structured process* models of reality. These are a means of structuring the functional analysis of observed situations for which an information system design is required. The paper then suggests a refinement to the model just described. It examines the relationship between the ERM and DFD techniques and proposes the use of logical access mapping(LAM) as a method of synthesizing the product of these two data modelling activities. An example is used to illustrate the derivation of ERMs and DFD from Petri nets.

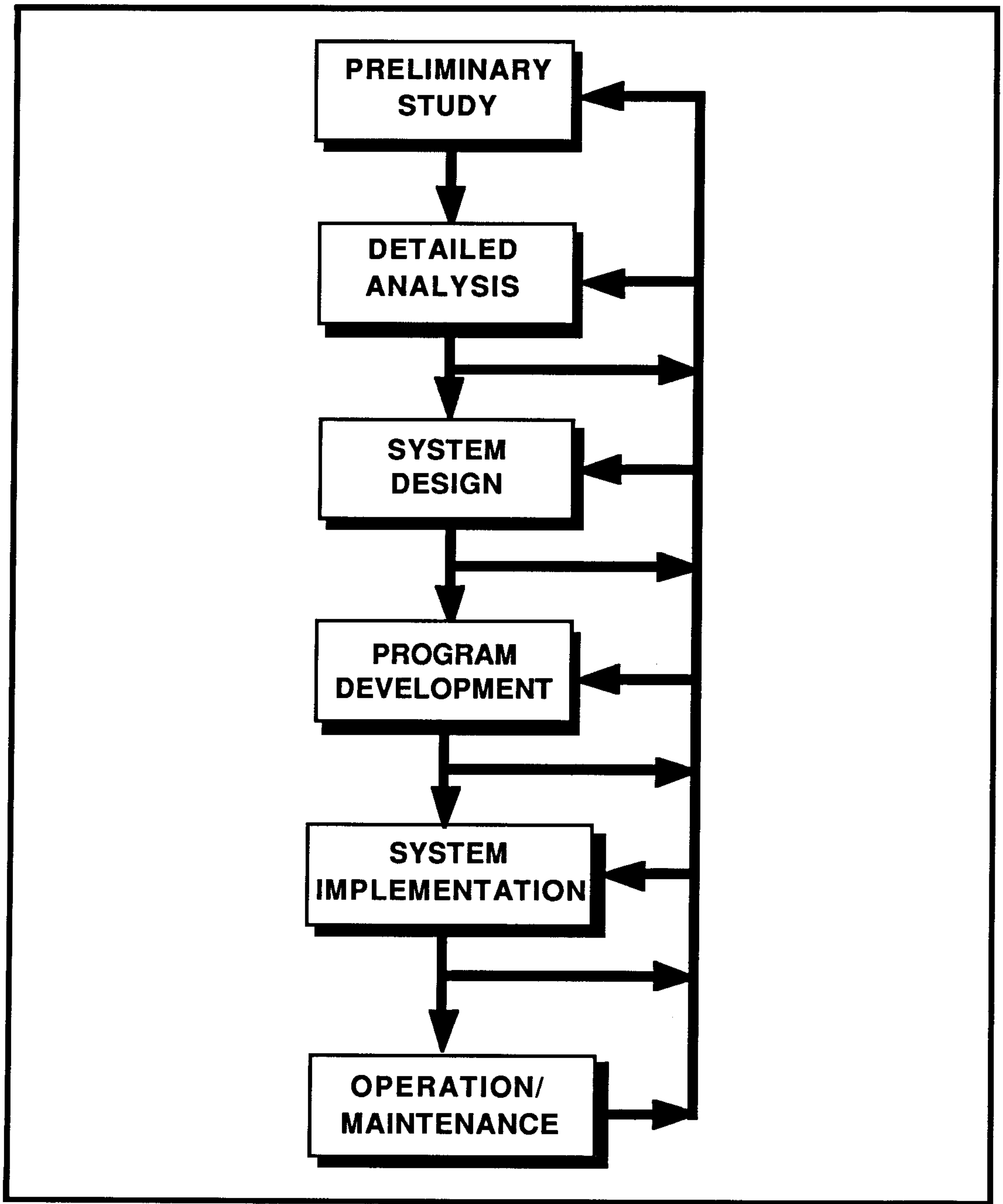
An example of the refined process model is given. 'Weak links' in this model are identified and further work towards establishing a method for formally proving data models is proposed.

INTRODUCTION

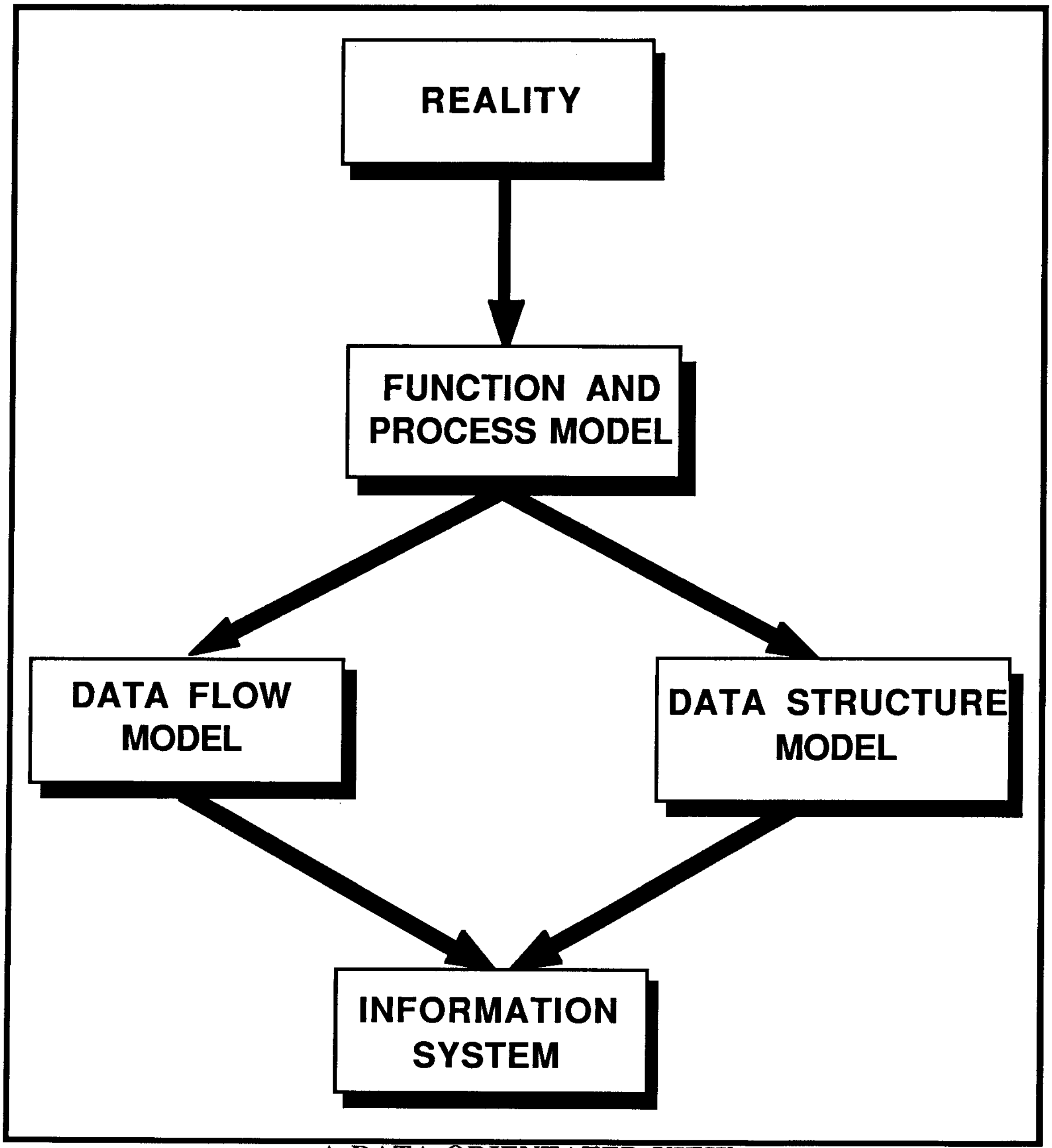
The evolution of information system development methods has by no means produced a consensus view of the sequence or nature of activities carried out by system designers. Throughout the literature, (for examples Lucas, [1985], Mantha, [1987], Necco et. el. [1987] and more recently, Sallis, [1988]) there is continuing reference made to the observable phenomenum of the system development life cycle (SDLC). Although acknowledged not to be a strictly sequential set of activities, the SDLC as shown in Figure 1, provides a framework in which to consider in general terms the events which occur during the development of information systems. For the most part, these events are considered as phases of development and say more about the organisational or production process of the work in progress than the techniques which are actually applied.

A more task-oriented illustration of the system development events which occur is given in Figure 2a. This Figure shows the production of a functionally decomposed representation of reality, usually in the form of organisational hierarchy models, in addition to function and process charts. Derived from this representation are both data flow and data structure models; the latter commonly being developed using ERM techniques. These techniques were devised by Chen, [1976] and extended by others since.

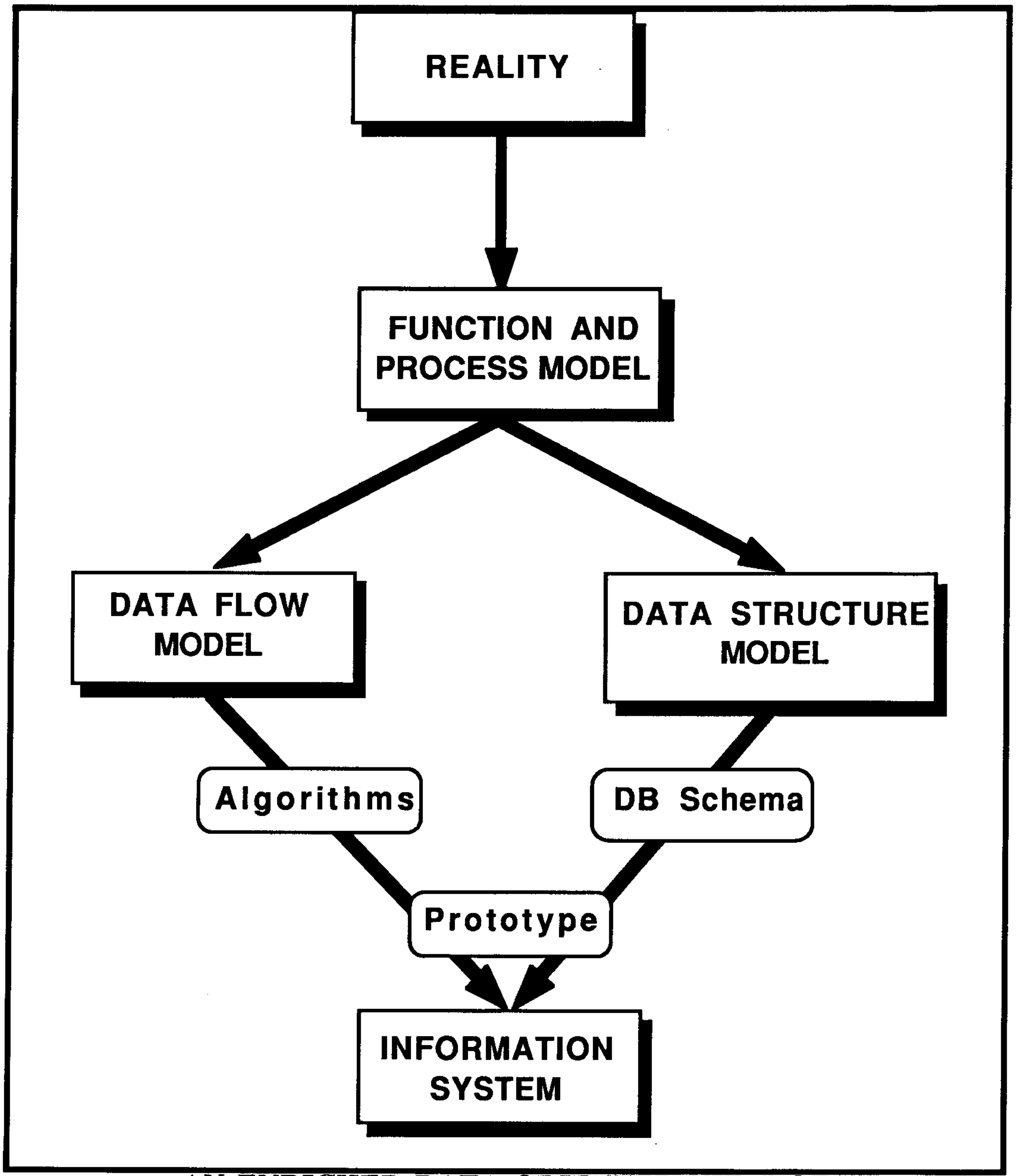
Figure 2b illustrates in greater detail the intermediate steps in proceeding from data models to an information system. From the data flow diagrams (DFDs), Gane and Sarsen, [1979], data processing algorithms can be derived and from the ERMs, a database schema can be derived. Debate concerning the exclusive appropriateness of each of these methods continues in the literature, but Mantha [op. cit.] has some empirical evidence which indicates that the resultant set of relations and attributes issuing from either DFD or ERM are imperceptibly different. There is a small variation in favour of the ERM method. Mantha's research used analysts who were trained using one or the other methods to produce DFDs and ERMs from a common set of data. Conceptually at least, this paper proposes the use of both methods to produce a composite data model in order to develop an integrated design for data flow and data structure which is directly implementable. The synthesis of these methods for general systems design is described in a previous paper by Benwell et al (1991).



THE SYSTEM DEVELOPMENT LIFE CYCLE
FIGURE 1



A DATA ORIENTATED VIEW
OF THE SYSTEM DEVELOPMENT PROCESS
FIGURE 2a



AN ENRICHED DATA ORIENTED VIEW OF THE SYSTEM DEVELOPMENT PROCESS
FIGURE 2b

Together, these provide input to the construction of a prototype which may in turn become the final information system, or more likely be used as the *user requirements specification* (URS) [Sallis, op. cit.]. Production of the prototypes (specifications) in this way are lately being facilitated using computer aided software engineering (CASE) tools and fourth generation languages (4GLs), Sallis, [1989].

Figure 3 redefines the elements of the process in three primary ways.

1 The inter-dependence between the DFDs and ERMs is explicitly represented. It is proposed that logical access maps (LAMs), McFadden and Hoffer, [1988] can be used to synthesize the two resultant models.

2 The inclusion of *structured process models,* in the form of Petri nets, as a rigourous means of representing the functional decomposition activity.

3 The taxonomy of the process which indicates that both functional decomposition and structured process models represent *reality*, whereas the data models, algorithm and database descriptions represent the *information system.*

Any representation of the reality depends upon some method for categorising and defining what is being observed in a given situation. For example, for any situation being observed it may be desirable to categorise items as entity types or processes. During the observation, all phenomena and their most obvious situation-related processes are then classified. For instance, in a VEHICLE RENTAL situation, a CUSTOMER and a VEHICLE would be classified as entity types. This method, with some variations, has been described as an object-oriented approach to systems analysis, Bailin, [1989]. In ERMs entity types may be people, objects or events. In structured process modelling the emphasis is more on processes which relate to the dynamics of information in reality. Using this method, the reality of the situation being observed can be described in terms of its data and processes. The next step is to produce an ERM and DFD as shown in Figure 3.

Whilst this approach has proved successful over a wide range of applications, the link between the functional decomposition model and the ERM/DFD is considered to be 'weak'. That is to say the transformation from one to the other depends greatly upon the knowledge, experience and intuition of the system developer. It is proposed therefore, that some more rigourous intermediate step is needed to strengthen the interface between the two models. The intermediate step suggested here is the use of rigourous state/transition nets, and in particular, Petri nets. These are described later in the paper.

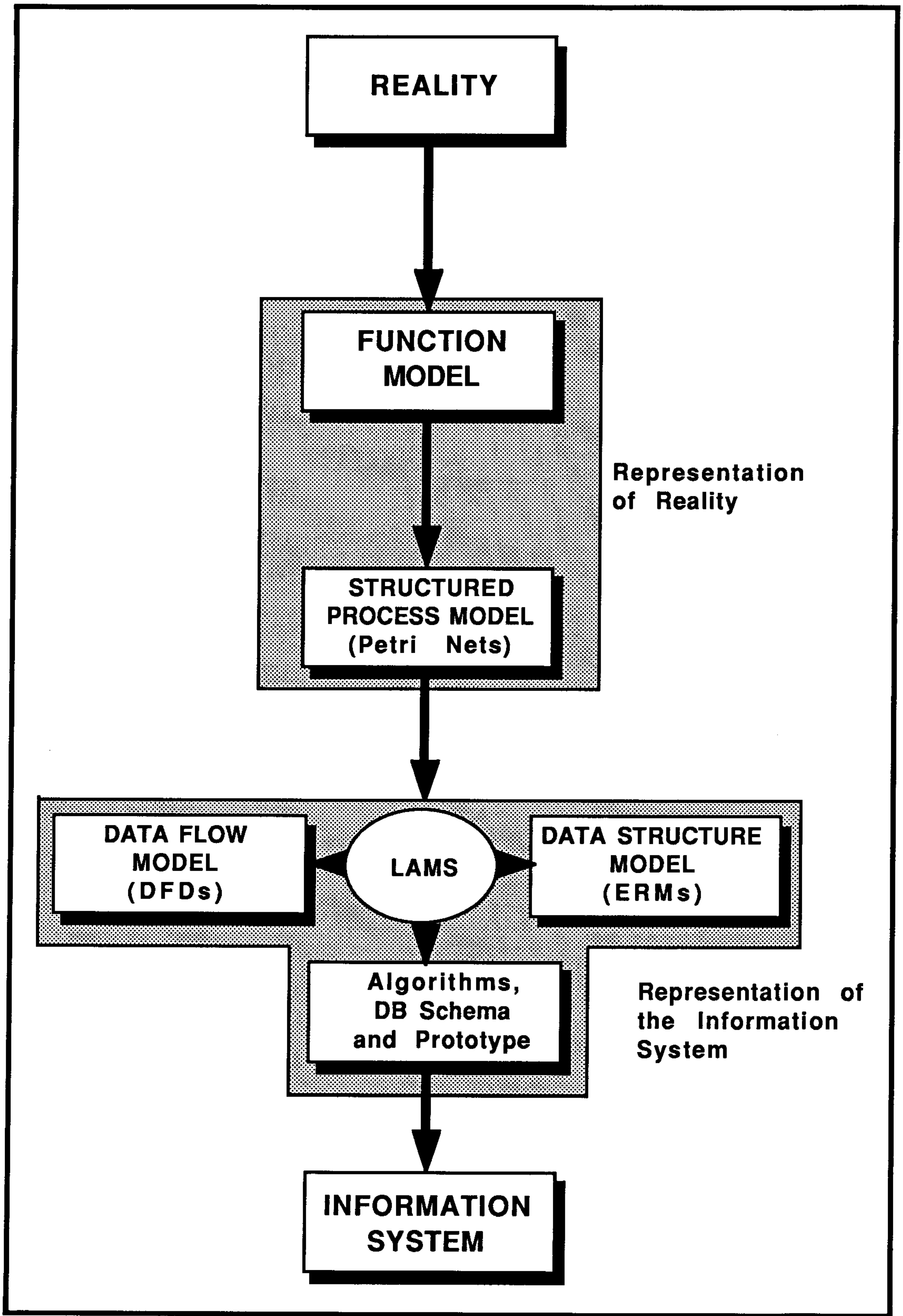
The next 'weak link' identified in this process definition is that between ERMs and DFDs. This paper proposes the use of LAMs as a means by which the two models can be synthesized to provide a more rigourous model than is currently available. LAMs represent the database interactions necessary to support processes acting on data. This representation utilises components of the ERMs from which database structures are derived. Given that DFDs represent the flow of data between processes in the information system, then LAMs have the potential to help identify any inconsistencies between a DFD and the associated ERM.

INTRODUCTION TO THE MODELLING TECHNIQUES

Petri Nets

Petri nets, Symons, [1982] are a scientific and mathematical tool to study systems and processes. Systems fundamentally have *components* and these components have *states*. A component may in fact be an entire system made up of other components, but its modus operandi can be described independent of the components. The state of a component is a representation of the relevant information describing its actions, whether past, present or future. These components may occur *concurrently*, in *parallel* or *serially*.

Petri nets (Pn or Pns) are designed to model these systems:- processes with interacting concurrent components. First, Pns are used as an auxiliary analysis tool. The system is modelled as a net and the net is analysed. The model is modified to correct for any known short fall in design. The system may then, via the Pn, be analysed and understood. Second, and more radical, is the concept of the design and specification of a process entirely in terms of Pns, a notion advocated in this paper.



A NEW CONCEPTUAL MODEL OF THE SYSTEM DEVELOPMENT PROCESS
FIGURE 3

Petri net theory was developed by Dr. Petri in his 1962 Ph.D. thesis, Petri, [1962]. The theory of Pns is based on *bag* theory, which is an extension of set theory. A *bag*, like a set is a collection of elements which belong to, and are wholly contained in a domain. In *bag* theory, however, elements may have multiple occurrences. In set theory an element is or is not a member of a set, and never a member of more than one set at the same time (the exception being disjoint sets). For a *bag*, an element may not exist, or may exist once, or any specified number of times. This definition does not exclude a *bag* from being, in the limiting case, a set. For the theory of *bags* see Peterson, [1986].

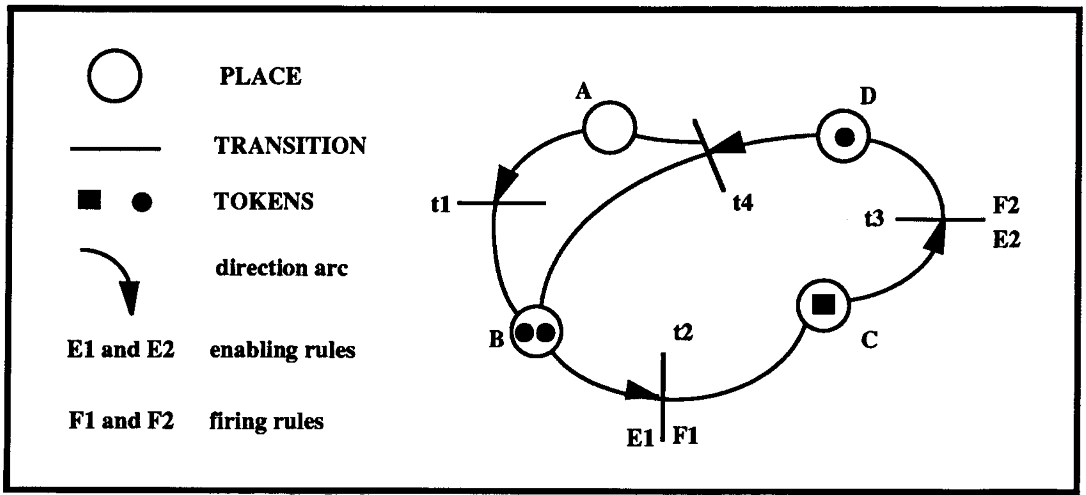
The properties and characteristics of Pns are such that they are very suitable for the representation and analysis of the flow of control and data information in systems, especially those systems which are composed of communication sub-systems which operate asynchronously and concurrently. Pns can be related to physical systems in several ways, but the simplest way is for the presence of a TOKEN in a PLACE (or state) to represent the holding of a particular CONDITION, and for the FIRING of a TRANSITION to represent the occurrence of an event enabled by the holding of the condition. Pns, historically, did not consider time. However they have been developed to a level where certain TOKENS can be created which represent time, cost and/or resources. When the firing of TRANSITIONS in a Pn represents events which occur in a physical system, a dynamic graphical representation shows the behaviour of the system under all possible and probable combinations of events.

Owing to their ability to represent concurrency, Pns have been widely used by computer scientists to model concurrent and parallel programs, Kirshnamurthy, [1989]. The main motivation has been to provide models which could assist in the understanding and solution of problems associated with concurrency, such as dead locks, competition for resources, synchronisation, mutual exclusion and critical races, Symons, [1962, p11].

Coloured Numerical Petri Nets

Coloured Numerical Petri nets (cnPn) are claimed to be the true generalisation of Pns and are better equipped to model practical systems. Each TRANSITION has an enabling condition and firing rule for each colour of TOKEN associated with the TRANSITION. The TOKENS have the following characteristics and may represent any attribute in a process;

- they may have any nature and value,
- the enabling and firing conditions are independent of each other,
- the TRANSITION enabling conditions refer to both TOKENS from input PLACES, firing TOKENS into output PLACES, and operations on TRANSITION memory data,
- they are removed from the input PLACES according to the relevant firing rules,
- they are received into the output PLACES according to the relevant firing rules,
- only one TRANSITION in a net may fire at a time; and if more than one TRANSITION is enabled, the TRANSITION to fire is chosen at random from a set of enabled TRANSITIONS,
- TOKENS can have any number of attributes, which may or may not change during a TRANSITION,
- the collection and distribution of the TOKENS in a net define the net's marking.



BASIC SEMANTICS OF A PETRI NET
FIGURE 4

Figure 4 is typical of a simple cnPn. Without colour the TOKENS have been shown by different shapes. PLACES correspond to system states, Marco and Buxton, [1987] and are usually the static components of a system (for examples see De and Sen, [1984]). These PLACES have information attributes attached to them. TRANSITIONS (or events by De and Sen, [op.cit.]) are happenings in a process and connect (or transform) information (or data) from PLACE to PLACE. While TRANSITIONS have been traditionally considered as atomic, this restriction need not apply in the more general case. Timed TRANSITIONS are not only possible but desirable.

The markings reached can then be studied to determine deadlocks and the nets efficiencies which could be in terms of time, cost and/or resources. The time, costs and resources may be logged through the life cycle by appropriate TOKENS. Although not portrayed in Figure 4 some markings may be unreachable, i.e. a particular net configuration is impossible. Some PLACES maybe unreachable due to the initial arrangement of TOKENS and/or the enabling and firing rules.

Entity Relationship Model

The ERM was first proposed by Chen [1976] as a means of obtaining a *unified view of data.* At that time a method of obtaining a logical view of data was becoming increasingly important and Chen aimed to provide a framework from which each of the three existing data models - the network model, the relational model and the entity set model - could be derived. Following Chen's paper, many researchers have embraced the concept and various modifications and extensions have been proposed in order to make the ERM semantically richer (see for example Chen, [1979]; Chen, [1981]; Chen, [1985]; Spaccapietra, [1986]; March, [1987]; Finkelstein, [1989]).

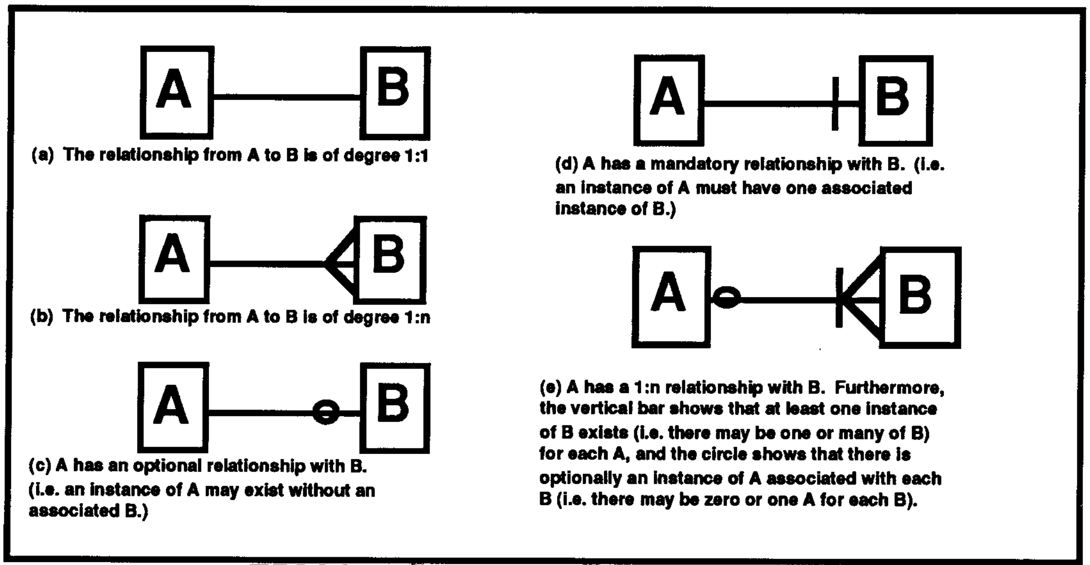
The principal characteristic of ERM is that they are developed independently of the physical structure in which it will be stored. This means that the modeller is primarily concerned with developing an appropriate representation of reality from the point of view of the user(s) of the data. Assumptions as to what is an appropriate representation of reality can be built into the model and the data modeller can then verify the assumptions or modify the model as necessary. The model should therefore, at any point in time, represent the modeller's current understanding of reality. This characteristic, combined with the fact that an ERM is able to be implemented in any one of the major physical database models, has gained the ERM extremely wide acceptance as an analytical tool.

Using the ERM, a data model will at least represent the existence of relationships between entity sets. A relationship can be specified in terms of the following properties which provide essential input for the development of a database schema:

(a) whether participation by specific entities within each of the participating entity sets is optional or mandatory - this characteristic will be termed relationship participation

(b) the cardinality or degree of the relationship indicates the number of such relationships in which specific entities within each of the participating entity sets may appear.

In general, relationships can be of degree one to one (1:1), one to many (1:n), many to one (n:1) or many to many (n:m). Figure 5 illustrates the diagramming techniques used here for representing relationships in terms of these two properties. The concept of entity sub-types, Ferguson, [1988] is also illustrated in Figure 5. The techniques adopted here are adapted from those proposed by Finkelstein [op. cit.].



ERM DIAGRAMMING TECHNIQUES
FIGURE 5

Representing the cardinality and participation of relationships facilitates the development of *normalised* ERMs from which sets of relations conforming to the relational integrity rules, Date, [1990] can be derived. There are however, various semantic characteristics of data relationships which can also be modelled, thereby enriching the model both as a database design technique and as a means for representing reality.

A data model should also include the specification of relevant attributes of entities. Obviously, this is essential if the database structure is to effectively support information requirements. For the data modeller, there is a very pragmatic reason for defining attributes early in the modelling process: analysis of attributes provides insight to the semantics of data relationships. Part of the process of attribute analysis is the designation of primary key attributes for each entity, which in turn enables relationships between entities to be represented by foreign keys.

Data Flow Diagrams

The data flow diagram, Gane & Sarsen, [1979] is a technique for representing the flow of data between data stores, external entities (i.e. entities outside the information system) and processes in an information system. There are two potential benefits to be gained from the use of data flow diagrams:

- as a communication medium between systems analyst and client, DFDs can provide the means to bridge the gap between the client's and the analyst's understanding of a system

- as an analysis tool, DFDs provide the means to identify which elements of a data structure will be accessed by processes.

DFDs are not directly translatable to a set of processing algorithms in the same way as ERM are to database schemas. Gane & Sarsen [op. cit.] advocate DFDs as an integral and essential component of the system design and that DFDs should be developed even before data structure modelling can proceed. It is the authors' experience that this is not necessarily so. ERMs and DFDs complement each other, and as implied by Figures 2 (a & b) and 3, the two types of models can be developed in parallel.

There are four major components of DFDs (illustrated in Figures 8 and 9): data flows (represented by arrows), processes (circles), data stores (open-ended rectangles) and external entities (rectangles).

ILLUSTRATIVE EXAMPLE

Having now discussed the modelling techniques the following example is used to develop the connection between ERMs, DFD and Petri nets (as illustrated in Figure 3). Consider a process that involves planning permits for buildings on land. Permits are issued to owners of land for the erection of buildings on their land and for certain alterations and extensions to existing buildings. It is required to create an extensible database of properties, permits, plans (to accompany the permit), owners and the person to whom the permit was issued. A distinction is made between owner and person. If an owner sells the land it is still required to determine to whom the original permit was issued. A simplifying assumption to the effect that there is no joint property ownership (a property can have only one owner at a point in time) will be made throughout this example.

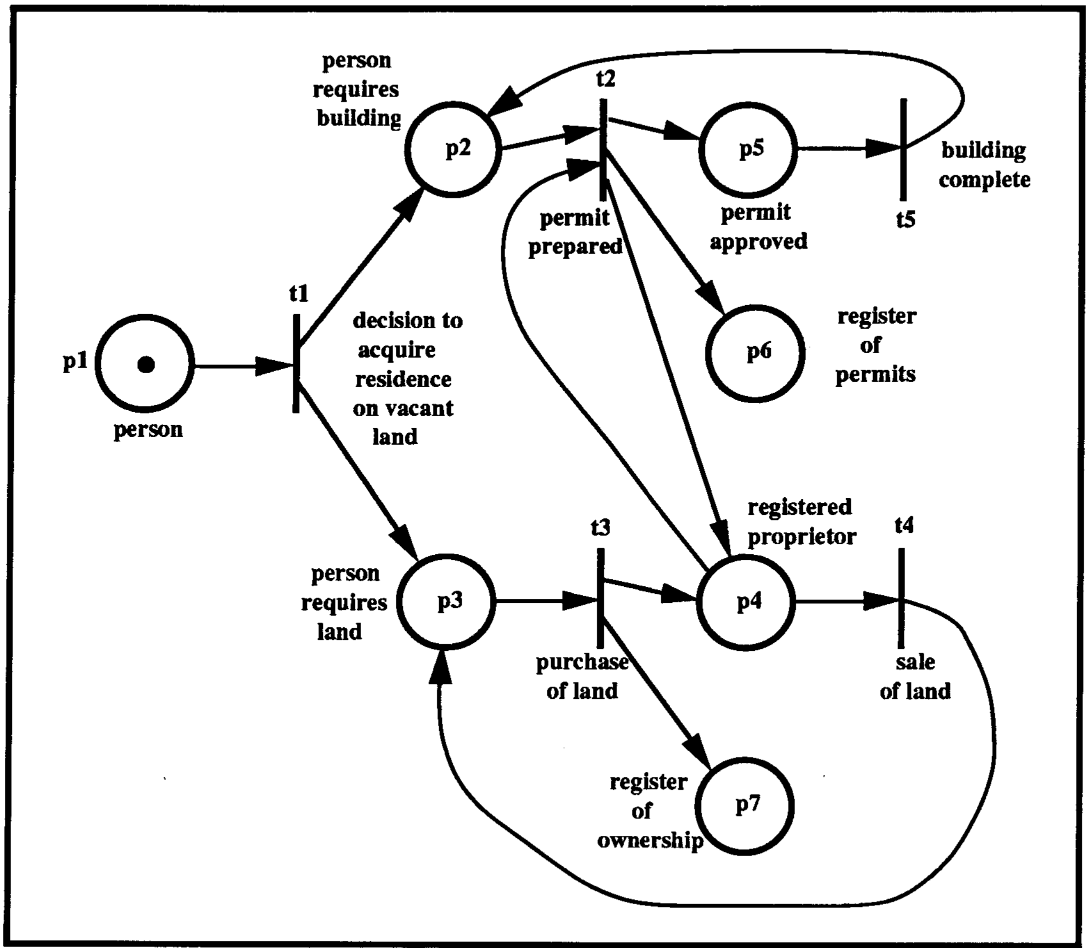
The Pn of the process is shown in Figure 6.

The net consists of the following;
PLACES:

- p1 PERSON.
- p2 PERSON requires building.
- p3 PERSON requires LAND.
- p4 REGISTERED PROPRIETOR.
- p5 PERMIT approved.
- p6 register of PERMITS.
- p7 register of OWNERSHIP.

and TRANSITIONS:

- t1 decision to acquire residence on vacant LAND.
- t2 PERMIT prepared.
- t3 purchase of LAND.
- t4 sale of LAND.
- t5 building complete.



PETRI NET FOR PLANNING PERMIT
FIGURE 6

The nominally passive components of the net are the PLACES (represented by circles) and the nominally active components are the TRANSITIONS (represented by boxes), Reisig, [1986]. The net models the process by which permits, people and owners form relationships, when information is stored and retrieved and when the relationships cease. PLACE p1 represents a set of people who may be considered to be prospective proprietors. Once t1 has fired two states are reached. First, the person may decide to build (or to carry out some alteration/extension) and, second, the person may decide to acquire land. The top half of the Pn represents the permit process while the lower half represents the process of buying and selling land. PLACES p6 and p7 represent the holding of historical information regarding all permits and all owners (in both cases, whether current or not). The recursive arc p4 to t2 represents the fact that a permit cannot be issued to a person unless they are a registered proprietor. An owner, after the firing of t1 is free to apply for numerous permits and to independently sell the subject land.

INITIAL MARKING						
p1	p2	p3	p4	p5	p6	p7
n	0	0	0	0	0	0

Table 1
Initial MARKING of the Pn
Note: n indicates any reasonable positive integer.

ENABLING RULES							
	p1	p2	p3	p4	p5	p6	p7
t1	>0	-	-	-	-	-	-
t2	-	1	-	1	-	-	-
t3	-	-	1	-	-	-	-
t4	-	-	-	1	-	-	-
t5	-	-	-	-	1	-	-

Table 2
TRANSITION Enabling Rules
Note: c indicates the presence of appropriate coloured TOKENS.

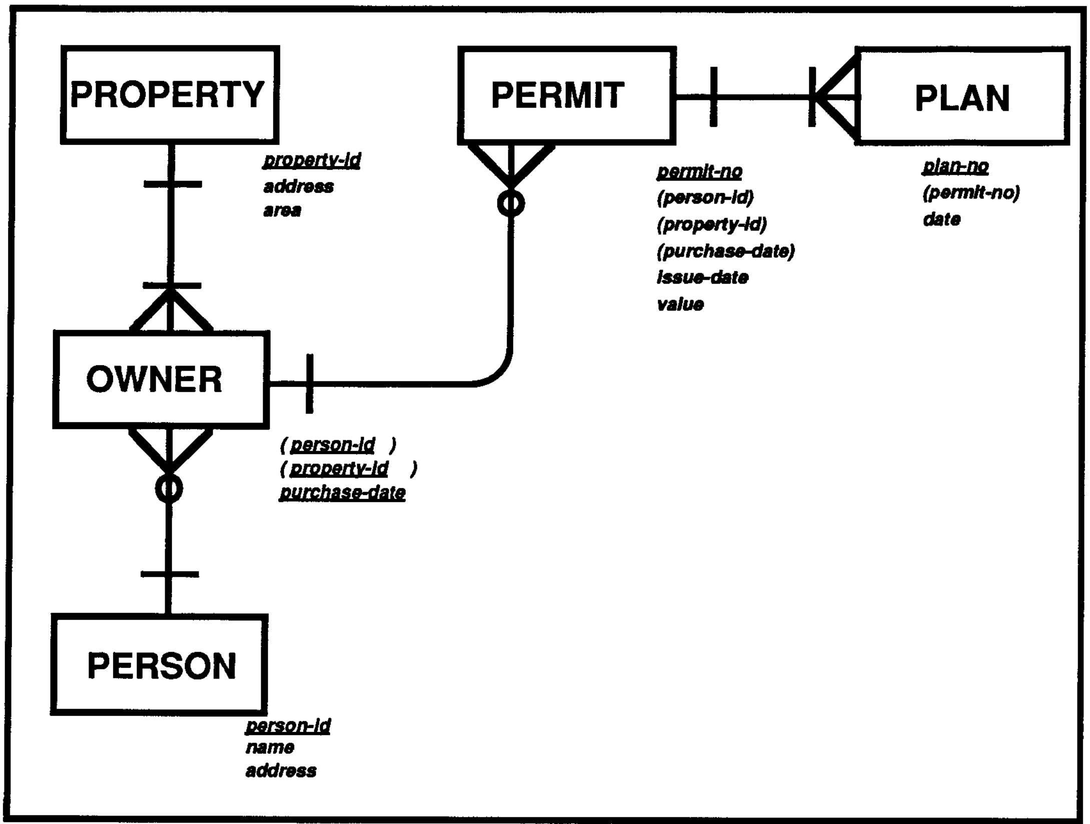
FIRING RULES							
	p1	p2	p3	p4	p5	p6	p7
t1	-1	+1	+1	-	-	-	-
t2	-	-1	-	0	+1	+1	-
t3	-	-	-1	+1	-	-	+1
t4	-	-	+1	-1	-	-	-
t5	-	+1	-	-	-1	-	-

Table 3
TRANSITION Firing Rules
Note: c indicates the presence of appropriate coloured TOKENS.

Tables 1, 2 and 3 show respectively the, initial marking, the enabling rules and the firing rules for the Pn.

The ERM corresponding to this example is given in Figure 7. If the entity PLAN is ignored for the moment, it can be seen that there is one central entity, OWNER, related to each of the other three main entities. OWNER has a m:1 relationship with PERSON - that is, for a given OWNER, there can only be one PERSON, but for a given PERSON, there may be zero, one or many OWNER(s). The semantics of the relationship between PROPERTY and OWNER are similar to this except that each PROPERTY must have at least one OWNER. An important point to note is that the assumption of "no joint ownership" still applies. The ERM in figure 7 supports historical ownership of properties, hence the m:1 relationship from OWNER to PROPERTY.

There are three component attributes of the primary key to OWNER: *person-id, property-id* and *purchase-date*. Including *purchase-date* as part of the key is necessary because one PERSON could, quite conceivably, sell and subsequently re-purchase a PROPERTY. The inclusion of *purchase-date* as part of the primary key thus enables a complete history of the ownership of such properties to be maintained.



ERM FOR PLANNING PERMIT
FIGURE 7

PERMITs are related to OWNERs through the inclusion of the primary key attributes of OWNER as a foreign key in PERMIT. Note that this implies relationships between PERMIT and PERSON and between PERMIT and PROPERTY, thus it is possible to determine to whom a PERMIT was issued, during which period of ownership it was issued and for which PROPERTY it was issued. The PLAN entity is included to illustrate the point that the database is extensible to include other related entities which are not necessarily directly related to the process currently under consideration.

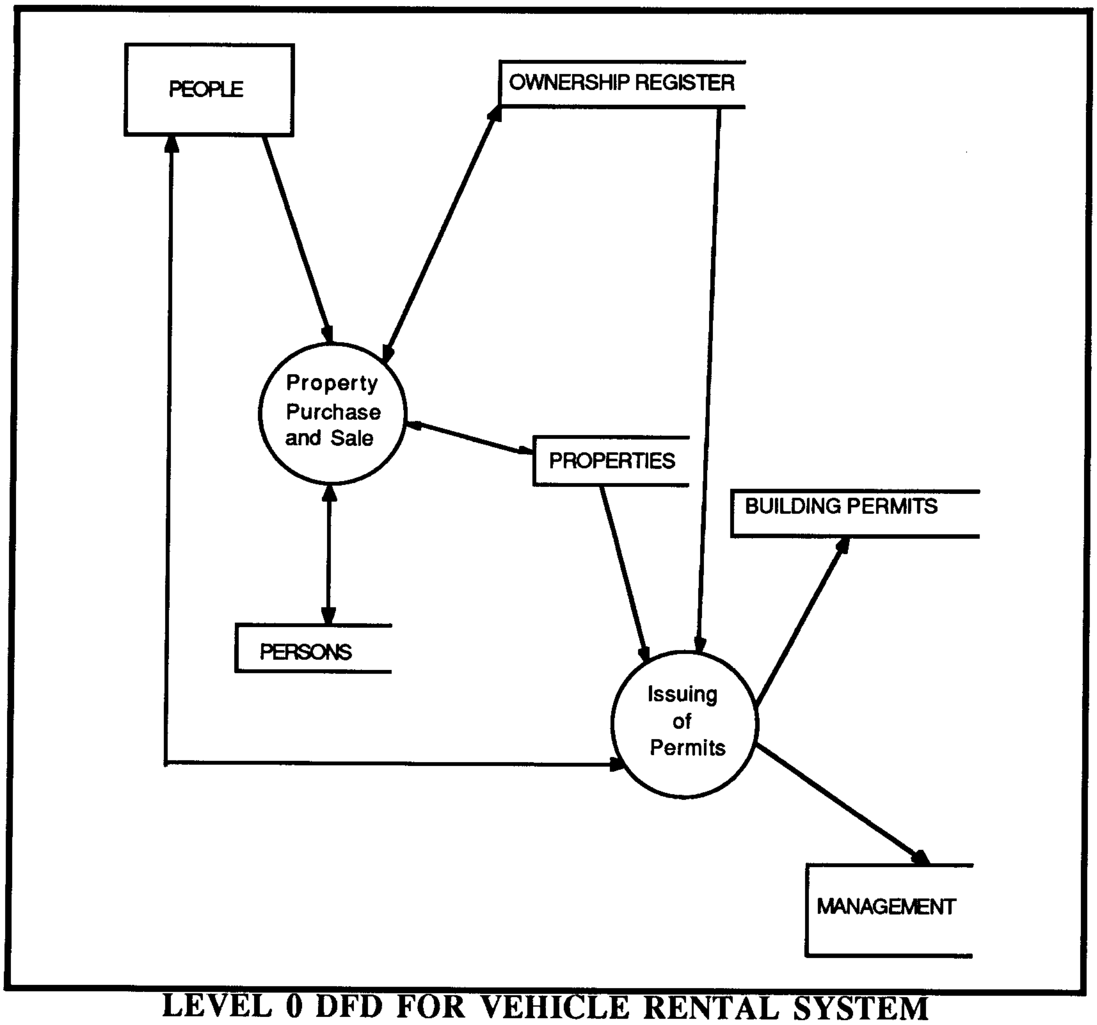
SYNTHESIS OF THE MODELLING TECHNIQUES

Consider now the connection between the Pn representation of the business and the ERM. The following correspondences can be observed;

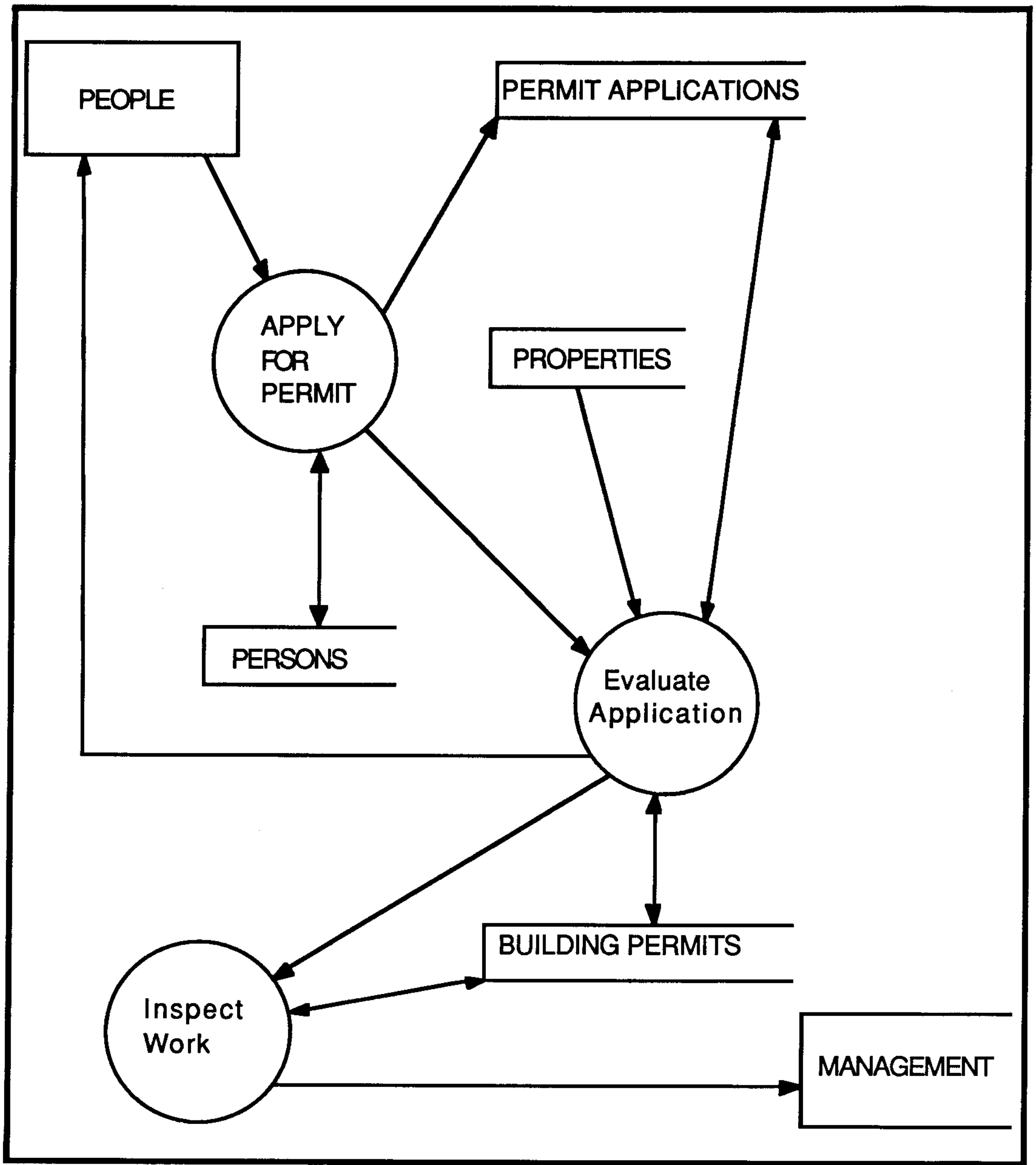
Object	Pn	ERM
land	registered proprietor (p4)	property
person	register of permits (p6) register of proprietors (p7)	person
permit	permit (p5)	permit
plan	permit (p5)	plan
owner	registered proprietor (p4)	owner

The existence of relationships between entities may not be readily identifiable from a Pn in the absence of coloured TOKENS. The presence of TOKENS in PLACES can indicate the existence of relationships between entities, therefore, until a Pn is analysed to determine the possible markings, it cannot be used to directly derive relationships between entities. Another pertinent point is that there is evidence of some connection between TOKENS in a Pn and attributes in an ERM. This, juxtaposed with the fact that attribute analysis provides insight to the relationships in an ERM, adds weight to the contention that the derivation of ERM relationships from a Pn is dependent upon an analysis of the marking of TOKENS in the Pn. While it has been demonstrated that there is, prima facie, a connection between: PLACES, TRANSITIONS and TOKENS on the one hand and relationships, entities and attributes on the other hand, the derivation of relationships and attributes from Pns is the subject of on-going research. It is concluded therefore that Pns are a valid precursor to ERMs and furthermore they are rigourous and capable of validation.

Figure 8 is the level 0 DFD of the vehicle rental information system. Comparing the DFD processes to the Pn TRANSITIONS, it can be seen that these processes are readily derived from the Pn - although there is not a one to one correspondence between DFD processes and Pn TRANSITIONS. The level 1 DFD of the *permit* process is given in Figure 9. In this instance there is no apparent analogy between the DFD processes and the Pn TRANSITIONS. Data processing functions at a detailed level correspond to the firing of TRANSITIONS and thus to changes in the markings of the Pn. Analysis of the TRANSITION enabling and firing rules, markings of the Pn and the nature of the tokens will provide insight to the data processing functions. This issue is the subject of further research.



LEVEL 0 DFD FOR VEHICLE RENTAL SYSTEM
FIGURE 8



LEVEL 1 DFD FOR 'HIRE OUT VEHICLE' PROCESS
FIGURE 9

CONCLUSION

The authors are singularly and collectively researching the matters raised in this paper. Special emphasis is being devoted to; first, the application of rigourous modelling of information processes; second, the relationship between Pns and ERM; third, the establishment of an integrated CASE tool using ERMs, DFDs and LAMs and fourth, the determination of the variables shown in Figure 10 and the resultant verification of the proposed improvements.

The SDLC has been re-defined here to represent the reality of the transition from a functional specification to a database definition and processing description. ERM and DFD techniques have emphasised the data driven development process, with the optimising influence of logical access mapping techniques. Petri nets have provided a new dimension for development control and a modelling mechanism which incorporates these other methods. This combinatorial approach has provided the basis for a means of formally proving the validity of data models and a way of managing and identifying logic and data relationship errors.

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Practical application of the software package MapInfo to link maps and database for forest management

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ABSTRACT

The management of forested land inevitably relies on a combination of maps and tabulated data. The major advances in the computer generation of maps have not found wide acceptance at the field level as the software is costly, the level of training high and specialised equipment is required. On the other hand the use of personal computers to collect and process data through spreadsheets and databases has been widely adopted. The key to the success of computer based systems at the field level is to provide simple tools that will be readily accepted.

Forest Science Consultancy Pty Ltd chose MapInfo to develop a system that could be used to generate maps and link data with maps. MapInfo is low cost, fully interactive with common industry software (dBase, AutoCAD) and can be tailored to meet specific applications through MapCode.

An example of the use of MapInfo in the inventory of the private forests in the Oberon Region is presented.

INTRODUCTION

While computer base mapping and geographical information systems have been developed to a sophisticated level, practical land managers rarely utilise this technology and the traditional tools of hand drawn maps, the sketchmaster and dot grid or planimeter are still commonly used.

Forest managers frequently manage large areas of land and maps depicting ownership, forest type, forest age, roads, water courses, dams, fences etc are required. In addition to maps, forest managers must monitor the forest as it grows each year and collect data to schedule harvesting of wood. This ensures even supplies to processing plants while at the same time ensuring that the forest is treated properly.

The data collection and manipulation aspects of forest management are now routinely handled through user friendly database and spreadsheet software. The link to land area is generally via manual entering of separately calculated areas from paper maps.

The most obvious need is to link these tools with a computer mapping package to allow non-specialist users ready access to an appropriate land information system. MapInfo was chosen as a low cost, user friendly software package that provided good links between maps and data. This package has now been field tested and found to be an excellent option.

The key features of MapInfo are:

- relatively low cost of purchase
- direct linkage to dBase
- menu driven
- requires only simple equipment to operate
- well documented
- strong linkage capacity to other mapping programs such as AutoCad
- customisation for specific uses available though MapCode add-on
- an active Australian mapping program allows purchase of already digitised maps

The key to efficient usage of MapInfo is the link between Pointfiles and Boundary Files. A Pointfile is simply a dBase record containing a number of fields. There are two fields - the X and Y Co-Ordinate which locate that datapoint either on a spherical grid (lat/long) or cartesian grid. Boundary Files are maps of discreet units of land which contain the ID of the boundary, the area and the X & Y co-ordinate of the centroid of the boundary. Using a single command, these attributes of a boundary are Updated to the appropriate Pointfile automatically.

Once a map delineating boundaries is created with MapInfo, the key data are placed in the Pointfile where information can be readily manipulated and displayed. A record from a typical Pointfile is shown below:

Field	Type	Description
XCOORD	Numeric	
YCOORD	Numeric	
COMPT	Character	Compartment Name (management unit)
PARCEL	Character	Parcel Name (aggregate of compartments)
OWNER	Numeric	
YEARPL	Numeric	Year Planted
AREA	Numeric	Area as defined by boundary
SPECIES	Numeric	1 = Pinus radiata, 2 = Eucalyptus spp.
LOGBY	Numeric	logging to be completed by

The Pointfile data can be filtered in up to seven layers to depict only those Pointfiles which meet the specified filter. A filter could be set, for example, to show only those Pointfiles which include Species 1, were planted between 1967 and 1972 and are within Parcel 20.

Searches can also be carried out on the Pointfile data. For example the search can be restricted to the Pointfiles which pass through the filter and lie within 50 km radius of the processing plant.

The values in the Pointfile can also be displayed thematically. A point symbol (such as a small square in varying colours) can be used to indicate the result of a search or the whole boundary represented by that Pointfile can be highlighted. This allows maps to be prepared for a range of purposes from the same data.

For repetitive enquiries or for specific applications, the Mapcode utility can be used to automate a wide range of operations. This makes it suitable for less highly trained operators to use, an important aspect when the program is to be used by a range of users.

APPLICATION

MapInfo was first used for a forestry land information system for the private forest resource near Oberon, N.S.W. To provide a sound basis for marketing these forests as one unit, the Australian Forest Development Institute (AFDI) commissioned an inventory of the forests. Maps at 1:25 000 scale covered most of the area, the western area 1:50 000 scale maps. Aerial photographs at a scale of 1:25 000 were taken of the forested areas. Each forest owner was asked to supply registered surveys or deposited plans and sketch plans indicating the approximate extent and age of their forest.

As Portion boundaries are indicated on the 1:25 000 scale maps and most owners have some form of firebreak along their boundaries, the ownership boundaries could be identified on the aerial photographs without ground control information.

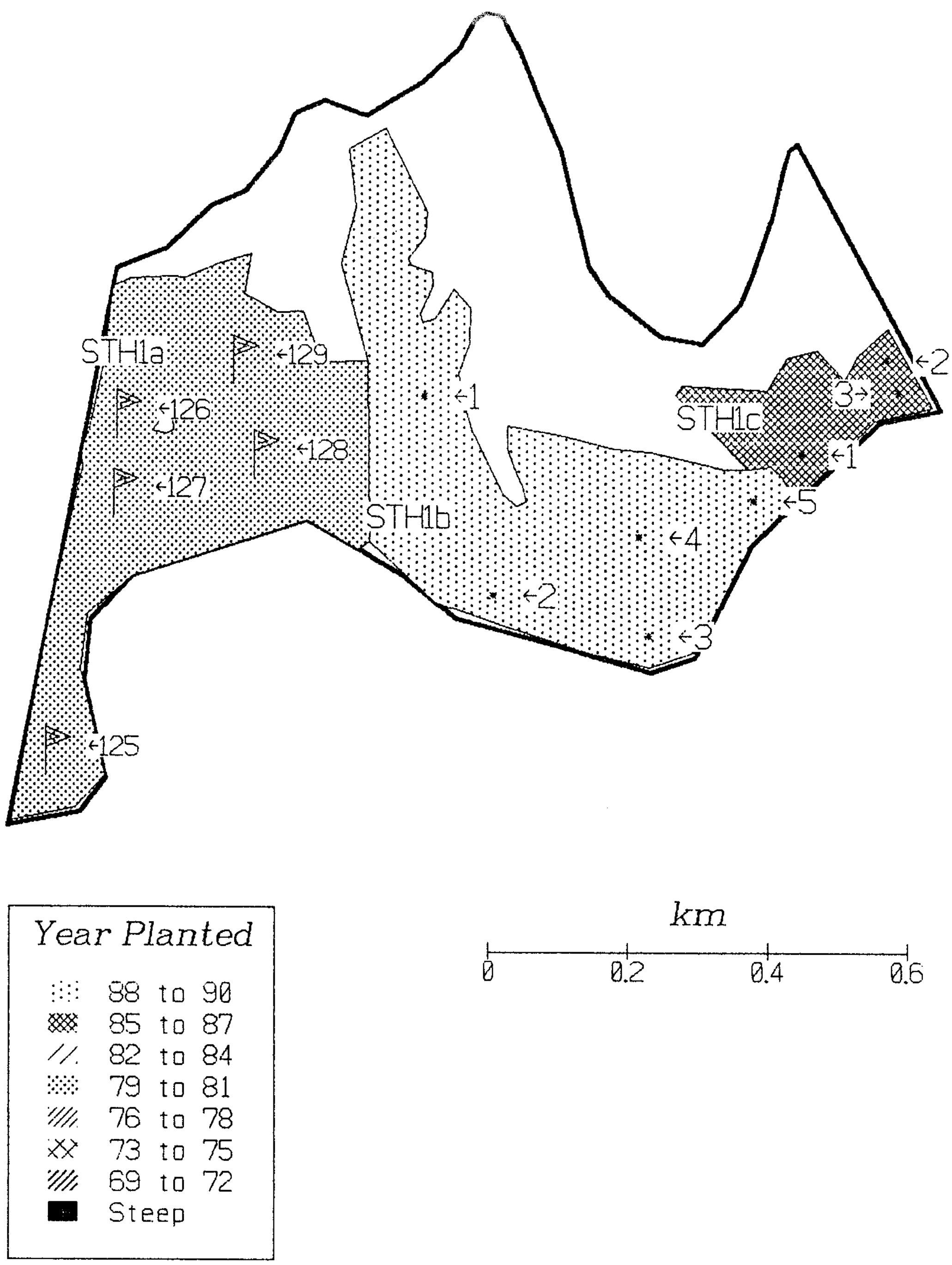
Base maps were prepared from the 1:25 000 and 1:50 000 scale maps. Using Mapinfo the Portion boundaries were transferred using a digitiser onto the base maps. This improved the accuracy of the ownership information considerably. Forest boundaries were transferred from the photos using MapInfo's ability to set up a transfer at any scale using a pointing facility to establish ground control.

Inventory sample points were located in advance on laser photocopies of the aerial photographs and when returned marked with actual location, were established as Pointfiles.

Once all the inventory was complete and boundaries adjusted to reflect assumed boundaries and the actual results of field inventory, the name and area of each boundary was Updated into a Pointfile containing the data relevant to the particular forest. Each owner was supplied with a simple map printed on a dot matrix printer (Figure 1) indicating their block, the extent of their forest, the age class of the forest and the location of the sample points. Steep land was identified from the contour intervals on the 1:25 000 maps and separate data was supplied. Pooled data was used to calculate the volume/ha of their forest and anticipated yields.

The AFDI report contained maps of each forest showing ownership, age classes and the road network.

Figure 1. An example of a simple forest type map indicating age class and sample plot locations. This map was produced at a 1:10 000 scale on a dot matrix printer.



CONCLUSION

This simple application of MapInfo enabled maps to be prepared at reasonable cost, enabled area to be calculated quickly and reliably, and allowed inventory data collected in the field to be integrated into the mapping system. The wide variety of map scales and map quality were handled by MapInfo to organise all the available data into one common format. Information was able to be presented at any desired scale, depending on particular requirements.

MapInfo has proven to be a most valuable tool for the low cost linking of map and inventory data into a practical information management system for field foresters.

CONFRONTING THE TECHNICAL ISSUES OF LIS

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ABSTRACT

This paper is designed to assist land information system (LIS) managers and decision makers who are facing the daunting task of selecting and implementing appropriate LIS technology to meet their present and future needs, within a limited budget, in a limited timeframe, in an increasingly complicated and expanding marketplace. It discusses current LIS software, hardware, networking and communications, and integration issues; as well as technical issues in LIS strategic planning, and selection of LIS technology. The paper deliberately concentrates on identifying ways to confront the technical issues in LIS, rather than on describing these issues in detail.

INTRODUCTION

Information Technology (IT) encompasses all relevant forms of technology designed to manage information in digital form. LIS technology in the context of this paper, is that part of IT which is of practical use in building a successful LIS.

Most recent GIS/LIS cost/benefit studies tell us that the cost of implementing a geographic information system (GIS) will comprise 40% or higher for staff compared to only 20% for hardware and software (Dickenson 1988). Also, any experienced LIS practitioners will tell us that overcoming data and institutional problems is far more important to successful LIS implementation, than selecting and implementing the appropriate technology. *So, why do so many LIS managers and decision makers find the thought of confronting LIS technical issues so daunting?* It's because they are quite familiar with the data and the institutional issues, but have little or no understanding of the technology, or a particular desire to get involved in the detail. They do not feel comfortable in a field which is seemingly getting more complex with each new technical offering announced by LIS suppliers. Despite this, they are expected to make sound purchases and plan for the long-term, so that their organisations can remain competitive and viable. In this context, "confronting" the technical issues is an appropriate choice of words.

The following discussion and advice is based largely on the author's experience and knowledge gained in implementing the New South Wales LIS, supplemented by a review of recent technical literature. It is written by, and for, someone with only a moderate background in IT, but who is faced with making the type of pragmatic decisions described above.

LIS TECHNICAL REQUIREMENTS

To appreciate how best to confront LIS technical issues, it is important to remember that any technology is not an end in itself. It is a tool used to support a particular application. The particular "user" requirements of that application will dictate the particular technical requirements. The user requirements which are most critical to successful LIS implementation, and examples of appropriate supporting technology, are:

- *the need to rapidly access large volumes of spatial data* through mass storage/retrieval technology coupled with a high-speed processing architecture and high-speed communications networks.

- *the need to manage a large number of static historical documents* through improved image-based data technologies.

- *the need for rapid ad hoc enquiry capabilities* through relational database and standard enquiry technologies.

- *little need for on-line transaction processing* allowing the extensive use of client/server architecture using networked workstations and PCs.

- *the need to perform integrated spatial/textual enquiries* through specially designed spatial/textual databases

- *the need to integrate data from disparate sources* through the implementation of technical standards in software and hardware, and in networking.

Because of the need to handle spatial attributes of land information, chosing appropriate GIS technology is a major technical issue in LIS implementation.

WHAT ARE THE ISSUES?

This topic could have been approached in a number of ways. For the purposes of this paper, the technical issues of LIS have been divided into two categories:

Firstly, the *software*, *hardware*, *networking and communications*, and *integration* issues with which LIS managers and decision makers need to be familiar, because of the capacity of the technologies to meet the LIS requirements described above.

Secondly, the issues associated with the processes of *strategic planning* and the *selection* of this technology, because of the importance of these processes in selecting and implementing appropriate technology.

The equally important issue of technical *standards* has not been discussed separately, but is raised at appropriate times within each category. Standards play an important role in protecting investments in hardware and software, software maintenance and enhancement, as well as user and programmer training. Some technical issues associated with *data* (interchange etc) system design (relational DBMS etc) and people (user interfaces etc) are similarly covered.

Technical issues associated with *acquisition*, *installation* and *operation* (contracts, outsourcing, disaster recovery etc) are not covered. Neither does the paper address the future technical issues which LIS suppliers and researchers need to address now, to meet future user needs.

SOFTWARE

As a general rule, it is not necessary to understand the exact technical details of how the software works, only whether it will meet your functional requirements. The functions required in LIS applications are usually categorised under the headings of data capture, maintenance, manipulation, access, output and distribution. Details of these basic functions can be found elsewhere in numerous publications and actual technical specifications. In the present and emerging technical environment, the following software issues deserve special consideration by LIS managers:

Image-based Technologies

The Image Processing of remotely sensed data, heralded in the 1970's as a major LIS tool, has still failed to yield its promise of providing a constant, accurate source of land-related data. The introduction of higher resolution SPOT data may see some improvement in the 1990's, but it seems that the major use of remotely sensed Image Processing will be as a rectified (but not enhanced) colour image overlay onto GIS vector data, which is linked to detailed operational land data sources. This application should not be overlooked in chosing GIS equipment, even in purely urban applications.

In contrast, Document Image Processing (DIP) is set to be bigger than the PC revolution of the 1980's. DIP can entirely replace paper storage for static documents, reducing transaction times, storage facilities and increasing work quality and quantity. In LIS applications, documents such as land dealings, site sketches, photographs of buildings etc could be stored on CD-ROM etc, indexed by a GIS, and output in response to an enquiry about a chosen area. A user could see the area identified area and possibly avoid a site visit.

User Interfaces

The human interface to most GIS packages remains their greatest impediment to the widespread use of such systems, and maximisation of the use of data in the system. The principles of a good user interface are: WYSIWYG, universal commands, consistency, simplicity, modeless interaction, user tailorability (SLIC, 1987).

Systems should have Graphical User Interfaces (GUI) which use pull-down menus and windows (icon-based interfaces which show the command options available to the user in each step) to replace command-based interfaces which require the user to remember the required command languages and database structures.

The industry standards for Graphics and Windowing environments are X-Windows for UNIX-based workstations, and MS-Windows for PCs. X Windows is vendor-independent network transparent window system which is the defacto industry standard for building windowing applications. It covers the way in which data is represented and organised on a network, allowing simultaneous views of the same or different databases. These standards should be insisted upon if windows applications are deemed essential.

Operating Systems

In recent years, UNIX has gained enormous prominence in the market place as an "industry standard" non-proprietary operating system, spanning the range of proprietary hardware platforms. This role has now moved from the workstation platform (for which UNIX is ideally suited) to minis and mainframes, for a variety of reasons. UNIX is also suited to the distributed resource architecture model (see Hardware section). Even IBM is now complying with international efforts to produce such a "standard" operating system. Users should insist on one operating system across the range of computers in their LIS, and should seriously consider adopting UNIX as the LIS operating system.

MS-DOS is the current defacto standard operating systems for PCs. Its major limitation is that it is single-user, single-tasking. OS/2 is designed to succeed MS-DOS as the defacto standard multi-user, multi-tasking operating system for PCs, although the speed of change has not been as great as expected. DOS familiarity, replacement costs and the introduction of MS-Windows has slowed this process. While UNIX ported to a PC (XENIX) is often criticised as an "over-kill" for PC applications, a mixed XENIX/DOS platform, running a number of simultaneous DOS applications under UNIX, may be a viable alternative to introducing OS/2. Such a strategy retains the familiarity and variety of DOS applications, within the uniformity of a total UNIX environment (from mainframe to PC).

Ported Software

Any software is designed and written to suit the host operating system. In recent times, many GIS packages have been ported to different operating systems. This is done to increase the marketability of the product across different vendor hardware platforms - rarely to gain any technical improvement in the product itself. UNIX-to-UNIX porting would normally be successful. However, moving outside the original environment e.g. UNIX to VMS, often results in a poorly performed and "flaky" system, unless the package is totally re-designed and re-written. Benchmarking is the only safe way to test such a product's performance. Products should not be chosen, "subject to porting to the required operating system". If the package is the best choice, consider changing hardware platforms.

Software Modularity

A "turnkey" system is a combination of hardware and software assembled by a vendor in order to satisfy a particular, well-defined user need. In the intended cases, such systems may be appropriate. However, such systems are expensive because you have to pay for the software you don't use, as well as that which you do. Such "bundled" systems should be avoided. The user should be free to buy what they need, when they need it.

Ideally, the system should be modular, so that apart from the basic functionality, it also offers specially developed applications as optional modules e.g:

- 3D thematic mapping
- natural resources management
- land use analysis
- urban and regional analysis
- socio-economic analysis
- network analysis and routing
- engineering design
- digital elevation modelling.

Software Customisation

Beware of products which are described by the vendor as a "tool-kit" of basic GIS functions. This simply means that it is a series of standard functions which the user will have to customise into a workable system for their needs. The flexibility and ease of use of the customising tools then become critical. Customisation by "macros" or strings of system commands only, are generally unsatisfactory methods to build important, routine applications.

Database Management and Query

Batty (1990) argues that all systems face common database management problems of back-up, recovery, auditing, security, data integrity and concurrent update. They must also share data between applications and distribute data across computers, while continuing to manage the previous problems. Such issues are well addressed in traditional "textual" LIS applications, but have tended to be neglected in GIS systems until recently. GIS should be no exception when it comes to these requirements.

Standard relational DBMS provide many of these features. However, one of the advantages of the relational DBMS model (over traditional hierarchical and network models) is the ability to "join" attributes in one table (entity) with that stored in another, to create a new relationship. The relevance of the "join" function to LIS/GIS applications, is that it provides enormous capacity for ad hoc enquiries so typically cited as a benefit of LIS applications. For these reasons, relational DBMS should be the preferred technology for new LIS applications.

A standard flexible query language is needed for access to relational databases and queries across distributed databases. Structured Query Language (SQL) is the industry standard, supported by all major RDBMS products. LIS users should insist on SQL capabilities, preferably extended to cater for spatial queries.

The prospective buyer must also be aware that there are many "born-again" DBMS packages which have some of the features of the relational DBMS and appear "tabular", but lack this true "join" capability (Montgomery, 1990). Also, because relational DBMS may not be suitable for manipulation and analysis of spatial data, few GIS's will use RDBMS to store and manage spatial data. This is not crucial, so long as the GIS can exhibit the required DBMS features. Alternatively, a GIS using RDBMS to store and manage spatial data should not necessarily be viewed as compromising its analytical capabilities. Benchmarking is the key to determining its DBMS suitability to user needs.

Continuous Mapping

The ability to view and manipulate spatial data without reference to the physical partitions in which it is stored, is an important GIS feature. Various techniques are available e.g. quadtree structure. Because these techniques can be implemented differently, benchmarking is the only satisfactory means of testing suitability. These "seamless" databases (which have no artificial boundaries) do not limit effective tracing operations and analysis of contiguous polygons. If analysis is localised, it is not such a problem.

Topology

Topology is fundamental to GIS/LIS applications, if it they are to produce the polygon processing and linear networking capabilities required. It is also useful to maintain spatial integrity. The issue of "vertical topology" or "shared primitives" remains a debatable technical advantage. Some applications may not require shared primitives to move in all cases of amendment, while shared primitives can be visually, rather than logically, managed. Solid user requirements and benchmark testing will answer this question.

Object Orientation

Unfortunately, object-orientation is becoming a "joke" expression in the GIS marketing arena. Old systems have suddenly become "object-oriented" - sometimes only referring to the simple fact that areal entities are explicitly recognised in the system. However, if the code is not written in an object-oriented programming language such as Smalltalk or C++, then the use of the term to describe the product may be more "sales hype" than reality. Systems written in an object-oriented programming language can have major changes made to parts of the system without causing unfortunate side effects. Also, generic code can be reused over and over again. Both these things mean that code is very much shorter and that bugs are much easier to find. This has advantages for the customiser (who doesn't have to use macros or the command language) and provides a more powerful and extendible system that will evolve with needs of organisation (Newell, 1990)

Software Design

Capabilities of software differ greatly in database structure and functionality, because they are designed to handle a specific application e.g. CAD/CAM, electricity facilities management, natural resource assessment. As Montgomery (1990) states:

> *"Many systems that grew from the drafting world have been rewritten to add spatial analysis functionality, and those whose roots are in spatial analysis have enhanced the mapping precision with which maps are created. The net result is that the software descriptions provided by most vendors on the market are virtually indistinguishable (by first-time buyers) in the software capabilities being touted."*

Differentiating strengths and weaknesses is for experienced programmers or benchmarking.

In particular, GIS systems were originally designed for natural resource applications - not property-based applications. In theory, they can handle the peculiarities of parcel-based data because of their sound topological base, but the inherent design constraints of a particular product may limit its performance in this application, and it may not be able to be customised. Paschoud et al (1991) include - performance on high-density map data, definition of invisible boundaries, overlapping and related boundaries, versionising, and remote access, as the possible areas where the traditional GIS package may be deficient for property-based LIS applications.

Software Development

LIS applications will often require major software development to meet particular needs, especially in large organisations. Topical technical software issues such as software quality assurance, and application of CASE, should be considered by such organisations.

Desktop Mapping

GIS software and the simpler "desktop mapping" systems are now available on PC platforms. The adage "you get what you pay for" applies here - don't expect the same functionality, performance etc as a workstation-based product. Its advantages are - low cost, easy to install, easy to use, well documented, impossible to crash. Its disadvantages are that it is unable to handle all requirements (present, planned and unanticipated) of LIS applications requiring GIS capabilities. As long as is it is not intended to service a massive, multi-user, multi-departmental, distributed network of workstations; it may be a viable option. If you need to incorporate GIS without delay and your needs are simple, consider PC solutions as a safe method of implementing GIS within your LIS application (Boston, 1990). In such a case, an advantage is that data entered into the system can be later transferred into other GIS packages.

HARDWARE

Hardware determines the response times and the number of users, that a LIS can support. Fortunately, selection of suitable hardware is becoming easier as standards make price the major consideration for platforms. Again, a prospective user needs to know the implications of a particular hardware issue, not how the hardware works.

Processors - micro, mini, mainframe or workstation

In the past, the higher up the processor scale you went, the faster the processing speeds, increased memory and ability to handle most users and applications. Today, micro and mini solutions now overlap, with the workstation becoming the predominant element in LIS applications. The best advice is to concentrate, not on whether the proposed solutions are called PCs, micros or minis, but on whether the options can meet your precise memory and response requirements, while accommodating the number of users requiring access to the system. The configuration must provide ability to expand to accommodate new users, new applications and larger databases which new users will bring.

In chosing hardware platforms for GIS, it should be remembered that most GIS operations do not particularly require large amounts of calculation, but instead need to access a large and complex database, so that speeds and disk storage are more critical than processing speeds. A 32 bit workstation with 3-5 Mb of internal memory is sufficient for most GIS applications. GIS does therefore not run well under time-sharing on a large mainframe. This means that, for most LIS applications, integration of existing administrative textual data with the GIS spatial data demands solutions other than the "cheap" one of putting spatial and textual data onto the same existing mainframe.

As micro-computer usage grows, and workstations become less expensive, networked 32bit workstations now provide the best platform for many LIS communications, manipulation and presentation requirements. The new RISC (reduced instruction set computing) architecture is the preferred workstation technology partly because UNIX is best suited to RISC and vice versa (SLIC, 1987).

Distributed Resource Architecture

Sharing of computer resources through client/server architecture will be one of the most prominent computing models in the 1990's. Networked workstations, with a central database server, provide expansion flexibility which is cost effective, permitting logical increments, and preventing system slow-downs and degradation, by spreading processing across multiple components.

Parallel computing

GIS applications are characterised by the need to handle large datasets and low precision and repeated processing of the same operations on the same data elements, and are I/O dominated with comparatively little mathematical manipulation. That is, GIS applications exhibit a high degree of "parallelism". Therefore, machines with massive parallel architecture can be expected to supply significant improvements to GIS performance in future (Hendley, 1990).

Mass Storage Devices

CD-ROM is now compact and portable. It is a low cost method of distributing central data to remote users, creating greater scope for new applications. Optical Storage in general cannot be surpassed for back-up, and now even for day-to-day requirements, where gigabytes of data are involved. Mass storage devices will get bigger and cheaper CD-WORM (write once read many) provides true erasable memory on CDs which will remove data storage and retrieval problems. This will result in on-line databases for LIS which will remove need for users to update their copy - just toss it out, and bring in a new (up-to-date) copy when needed.

Storing spatial data locally may become the most viable way to rapidly accessing large volumes of spatial data at remote locations, as an alternative to high-speed communications. Spatial data could be put to the screen immediately on a remote workstation, while the textual component of the enquiry can be transmitted and processed on the host facility. The remote spatial data (which is less dynamic than the textual) could be periodically refreshed overnight by batch process. Such periodic re-mastering of copies of central database and distribution to remote user also ensures that a uniform database is used. Applicability of optical storage needs to be carefully assessed in each case, and requires expert assistance.

NETWORKING AND COMMUNICATIONS

This area of IT is easily the most jargon-filled and intimidating to LIS implementers. Advances in networking and communications technology are occurring at such a rate, that any statement of their present capabilities and applicability is quickly made obsolete. Fibre optics, packet-switching, ISDN etc promise high speed transfer of large volumes of data in the near future, although its cost-effectiveness for graphics applications is yet to be determined.

The area in which they will have their greatest impact in LIS is probably in providing remote LIS users with rapid on-line access to large volumes of spatial data, in response to an integrated LIS enquiry. However, as discussed in the Hardware section and in Hart & Bullock (1990) mass storage devices may eventually overcome these problems. For the above reasons, expert advice should always be sought on networking and communications requirements and options, when required. Don't attempt to do it yourself.

INTEGRATION

A distinctive feature of LIS applications is the high degree of "integration" involved in implementing working systems. This integration is at different levels. For example, conceptual, logical, and physical. Those software and hardware issues relating to the integration of data and systems are now discussed.

Conceptual Integration Models

The successful integration of different, physically separate systems into one logical whole still remains a "leading edge" LIS technical activity. There are several approaches to the problem, depending on the level of integration required: the Hub/server model used in Vaucluse, France; the Hub model used in NSW; the Hub/gateway model used in Queensland; the Nodal model used in South Australia. All of these models are designed for integration at a State level, but can be implemented within an organisation as well.

Spatial/Textual DBMS Integration

Buyers should carefully examine how spatial data and text are to be integrated in a total system. There are many options, ranging from a single DBMS for all spatial and textual data, to the interfacing of two separate DBMS products. In many LIS applications requiring GIS capabilities, it is unlikely that the DBMS for textual data used in a vendor-supplied GIS product, can also support existing textual data applications. In most cases, the textual DBMS already exists, and the requirement is for the GIS to interface operationally to an existing vendor database. This is particularly the case in Local Government systems, where the vendor chooses a GIS to add to their existing property system. The speed and functionality of this interface, plus the commitment of the vendor to support it, must be tested. True object-orientation will make the different approaches less critical. The interface language should ideally be SQL-based.

Electronic Data Interchange

Recent agreements on Electronic Data Interchange (EDI) promises the possibility of transparent text data flow laterally between systems. It is an emerging standard for exchanging documents between organisations, primarily for invoicing and ordering, replacing paper-based transmission of data. It will have LIS applications, but does obviously not currently spatial data transfer.

Spatial Data Transfer

The transfer of spatial data (stored in proprietary data structures) between different GIS systems, remains difficult, tortuous, and fraught with error. A GIS must be able to demonstrate its ability to receive and export data in the required GIS format specified by the authorised State LIS supplier. In the short term, this may be achieved via a specially written 1-to-1 translator or via an intermediary proprietary standard (e.g. SIF). The success of the transfer can be easily tested.

The long term solution to this problem is GIS via the proposed Australian Standard for Spatial Data Transfer (SDTS). Buyers need to establish the vendor's commitment to support this standard by written guarantees and by assessing the vendor's level of participation in the Standard's development. The suitability of SDTS, which has its origins in batch transfer of large volumes of spatial data, rather than for on-line transfer of data over telecommunications network, remains an issue to be further tested.

Open Systems Interconnection

OSI provides non-proprietary multi-vendor solutions through compliance to the OSI reference model. OSI-based products can now be confidently specified and, to a lesser extent tested, using the Australian Government Open Systems Interconnection Profile (GOSIP) as a guide. GOSIP has been produced by the Commonwealth Information Exchange Steering Committee and endorsed in October 1988 by Federal government, that all future Commonwealth acquisitions support OSI. GOSIP provides specific guidance to suppliers and agencies.

Buying products which adhere to OSI standards also protects investment in equipment and manpower through the ability to select the best computing systems from multiple vendors, and avoid pain of extensive migration. New technologies can be incorporated without making present technology obsolete.

Integrated Data Technologies

Advances in integrating processed image data into LIS, have been touched on in the Software section. The integration of this technology with text and other dat can be presently be achieved by interfacing different systems within the one configuration. However, new technologies are emerging that enable LIS applications to consider the transparent integration of images, vectors, voice, video and text. This integration of different data technologies emphasises the fact that "GIS" technology is not the core of an LIS. It is one of several technologies which needs to be integrated to form a uniform system.

STRATEGIC PLANNING

IT Strategic Planning is needed to determine scope, cost and timetable for the acquisition and implementation of technology. In this process, decisions are made on a variety of technical issues. In addition to those technical decisions mentioned in the previous sections, other strategic decisions include:

Capacity planning: don't be constrained by the limitations of your current technical operating environment. You must cater for growing needs. The maximum number of users and acceptable response times must take this into account. You should anticipate that, after you've worked with the system for a short time, new ways to use the LIS database will be discovered.

Technical strategy: an "intercept" strategy of planning and designing for the standards and technologies of a few years hence, is probably the most appropriate strategy to adopt for LIS development.

Phased implementation: if finance allows, phase implementation by acquiring the basic "starter" system, and buying off your own contract as the need arises. This also takes advantage of new models and falling prices.

SELECTION

In this section, it is assumed that a feasibility study and user requirements specification have been done properly, and the decision has been made to acquire appropriate equipment for the LIS application. The detailed steps in the tendering, interviewing, benchmarking and selection process are not addressed here.

Pearce (1990) identifies the most common problems with a chosen system as:

- doesn't meet user's expectations
- can't be made operational in required time
- inadequate performance
- cannot be expanded for future growth
- requires significant development before it is usable
- not being developed or enhance by the supplier.

To avoid these problems, the following technical issues deserve special consideration by LIS managers in selection of appropriate technologies:

Buying off-contract

Government supply contracts often have a GIS product which can be purchased without going to tender. The temptation is to compromise your technical requirements by buying this product. The advantages are obvious - avoiding lengthy and costly selection and benchmarking exercises, vendor government support already in place. The pitfalls are also obvious - a limited choice, the original choice was made for other purposes, perpetuation of an earlier (possibly now outmoded) decision. Buying off-contract is rarely beneficial unless the contract was recent and the organisation has similar needs.

Technical Specification

The Technical specification should simply translate the User Requirements into technical requirements. It should not be loaded with a particular technical preference which may prevent selection of new or improved technologies. Also, don't re-invent the wheel. Other organisations with similar LIS requirements may have recently prepared a Specification which you can use as a guide.

Consultants

Experienced consultants are probably best employed to assist in the preparation of Technical Specifications, because this task does require a detailed knowledge of the technology which no organisation can possibly maintain internally. Consultants vary considerably in skill and experience, so previous satisfied clients should be the main selection criteria. Consultants should not have any product affiliations. Their experience should be retained in the organisation by allocating internal staff to assist in the consultancy.

Site Visits

Existing sites nominated by suppliers should be at least contacted and preferably visited, to see how the system performs and to see if the results of their benchmark tests can be used in the buyer's application.

Benchmarking

The function of a benchmark test is to test tendered systems for functionality and performance, against the user's Technical Specification. It is often the only way to determine the suitability of the system. Users must try to find the best match of system capabilities with user requirements.

Benchmarks can become time consuming and prolonged for suppliers and buyers. For small acquisitions, check if others have recently benchmarked similar application, or piggy-back a current similar benchmark by arranging to have your requirements added to test. Guptill (1989) recommends that the user should determine the appropriate level of benchmark testing by asking:

- does it have the software functions required to perform the necessary applications

- will the hardware components perform these functions in an efficient manner and provide for growth with respect to data quantities, users and analysis

- does the series of benchmark tests provide information to answer these questions.

If the systems being tested meet certain minimum standards, concentrate on the critical requirements. The test should also measure the amount of manual effort needed, as well as actual response times. Design the tasks to expose potential system inadequacies in:

- data integration and management
- a few key analytical functions
- transparency of data structures
- human interface (ease of learning/use)
- modularity
- maintenance
- security
- multi-user applications
- richness of query language
- integration with external databases
- ability to customise the system

McLaren (1989) offers experienced advice on conducting benchmark tests:

> *"All GIS applications vary sufficiently to render the fabled "off the shelf" type products inadequate. Therefore, all buyers are faced with the challenge of customising the system to merge with their specific environment. The Benchmark must be designed to force the supplier to implement buyer specific functions, thus allowing the evaluation of the available customising tools ..... All salesman play tricks to impress potential buyers and GIS suppliers are no exception. Most of the deception is aimed at demonstrating performance beyond that achievable through normal operation of the system. The normal tactic is to use small datasets .... The same illusion can be achieved by using a special hardware configurations with fully configured memory or specialised graphics boards ..... Use realistic datasets and ensure that the configuration used is that tendered ..... Suppliers will try to restrict the scope of the Benchmark to "safe territory" through strict adherence to demonstration strategy. Ad hoc Benchmark requests are a true insight into the system's and demonstrator's capabilities. Don't be intimidated!"*

Suppliers may also write special routines to perform the benchmark tasks with excellent response times. Such "hard-wired" solutions are not general purpose, and fall apart in production. Similarly, benchmark tests are not "canned demonstrations" of pre-extracted output. If in doubt, interrupt the process, ask to go back a few steps, and use different criteria.

Selection Process

There is little benefit (to the buyer) in delaying a choice until you decide between technically similar products, if either will do the job. Too often, technical people get obsessed with solving the question of which is the technically "best" system. Similarly, don't be swayed into chosing on the basis of which one offers the best "additional" functions, if these functions are not in the specification. In the end, price, level of support and other non-technical factors will determine the final choice.

Be prepared to modify your technical specification only if your user requirements are not compromised, and only if the tendering process permits you to do so. Don't delay your decision because of future technical improvements. No matter what you buy now, by the time contracts are signed, delivery taken, and training commences; there will almost certainly be a faster hardware platform to run it on, at a lower price.

Consider acquiring more than one package, if no single one does the job. If no system is suitable, consider waiting until the market improves. Study the quality of documentation and manuals - these indicate of quality of system support.

Vapourware

Beware of "vapourware". Promises of software improvements are sometimes used to clinch a deal, with little real commitment or knowledge on behalf of the supplier. Sometimes the new features/products will be available, but can't be demonstrated in time for the benchmark (particularly if the product is from overseas). There are no hard and fast rules - the difficult task is to distinguish myth from reality. If the supplier cannot produce a technical specification for the product/release, be sceptical. Never accept such a product without testing - it may arrive but not perform. It is usually unwise to base a selection on the promise of a new release. Add at least 12 months onto the suppliers promised release date in these circumstances.

Support

Maintenance fees include support (to sort out short term problems) and enhancements (to receive general improvements plus to incorporate your changes). You need to have a say in the future direction of the product you have invested in, so that it moves with you. User groups should be the mechanism for prioritising changes in the next release, not a social club. Your request may end up on the bottom of a long list of established, and more influential, users. The best advice is to be sure that the vendor is "focussed" on GIS/LIS applications.

CONCLUSIONS

The above discussion has attempted to show that the task of confronting the technical issues of LIS need not be as daunting as it may appear, for the LIS manager and decision maker. Guidelines for making a good technical selection include:

- have a LIS technical strategy in place before selection (produced with assistance of experienced consultants)

- make sure that Technical Specification reflects accurate User Requirements (long term as well as present) and stick to the specification

- use benchmark testing and site visits to resolve uncertain aspects of product suitability to your needs

- make a good decision (but not necessarily the "best" decision) and make it as quickly as possible

- remain in touch with current LIS technologies, and develop an understanding of where they are headed over the next 5 years.

The last point can be achieved in part by participation in a relevant professional association such as AURISA.

Ten years ago, the technology (or lack of it) was a major impediment to successful LIS implementation. Today, this impediment is rapidly disappearing with the move to "open" systems, system performance doubling every 3 years, hardware prices tumbling, and more research being conducted into LIS/GIS applications to give more and better system choices. Remember that your investment in technology is replaced every 5 to 7 years; but investment in data and people is expected to last 20 to 30 years.

In summary, be driven by your needs, not by the technology which is their to serve those needs.

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GEOGRAPHIC INFORMATION SYSTEMS: MIRACLE OR MIRAGE?

COSTS AND BENEFITS OF GEOGRAPHIC INFORMATION SYSTEMS IN LOCAL GOVERNMENT

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ABSTRACT

This paper identifies costs and benefits associated with the use of Geographic Information Systems in a local government context.

The technique of cost/benefit analysis is discussed generally in relation to GIS implementation projects, these general techniques then being adapted to specific examples of GIS implementation in local government organisations.

The ultimate cost/benefit ratio of GIS projects is found to be more sensitive to organisational and human resource factors than to variations in technical system capabilities.

INTRODUCTION

Throughout the past two decades, computer technology has had an increasing impact on individuals in both the work-place and in their private lives. Increased access to information available through computerisation offers our society benefits which were totally unforseen by previous generations.

In common with other great technological innovations however, computerisation also has a down side. Loss of privacy, repetition strain injury and alienation of workers are a few negative impacts often associated with this technology.

In 1977 Douglas Kirsner sketched Australian society as one where technology had become the dominant ideology. In such a society, he argued, technology is pursed regardless of whether or not it brings net benefits to mankind, or a greater individual realisation.

> "With the institutionalisation of rapid technological change there occurred the elevation of means to ends, or rather the entire dethronement of ends".[1]

It is timely to ask whether this statement is relevant to the implementation of Geographic Information Systems (GIS)[234] in local government organisations. More specifically we pose the question - Does the substantial financial investment in hardware, software, data acquisition and staff training associated with the implementation of GIS result in long term cost savings to the organisation and/or improved services to its clients? This paper employs the technique of cost/benefit analysis to address this question.

Structure of this Paper

Having questioned the cost-effectiveness of GIS implementation in local government organisations, this paper proceeds to explain why comprehensive cost benefit analysis of GIS projects should be seen as a prerequisite to the commitment of resources. Arguments related to financial and organisational factors are considered.

A brief introduction to cost benefit analysis is then followed by an outline of broad techniques which are applicable to evaluating GIS projects in local government organisations. The experiences of Warringah Shire Council and Yarrowlumla Shire Council are used to illustrate these techniques.

The paper concludes by identifying those areas where further research is required to refine cost/benefit techniques, and argues that the process of cost/benefit analysis provides organisations the opportunity to maintain control over the direction of technology within the work-place.

THE NEED FOR COST BENEFIT ANALYSIS

Financial Considerations

In the current economic climate all organisations, whether government or non-government, are confronted with cost minimisation in the face of demands for increased performance. Local Government organisations are particularly under pressure, facing reduced funding from State and Federal Governments and a declining revenue base from property rates.

Many of the arguments put forward to justify the implementation of GIS projects in Local Government relate to anticipated cost savings from increased efficiency and subsequent staff reductions. Experiences of organisations who have embarked on GIS implementation projects do not always confirm these initial contentions.

Sound financial management principles dictate that investment of the scale required for corporate wide LIS/GIS projects requires forward financial planning. Further, there is a corporate responsibility to ultimately justify such expenditure to the electorate. Comprehensive cost benefit analysis can satisfy both these requirements.

Organisational considerations.

Computerisation inevitably brings with it organisational change. It is pertinent that organisations consider how this structural change will best be managed to enhance corporate objectives.

The process of identifying areas within the organisation where costs and benefits are likely to occur provides a logical basis for review of existing operations, and stimulates crystalline thinking at a corporate and departmental level. Lack of a structured approach to assessing the organisational impacts of GIS can lead to corporate objectives becoming blurred. Even worse, overall objectives may become totally lost amid a haze of technical discussion preoccupied with the capabilities of the latest hardware and software.

By undertaking comprehensive cost benefit analysis at an early stage in the consideration of GIS implementation, organisations may develop an approach to management of structural change which will support corporate objectives. The investment of time and effort up-front in undertaking such an analysis is more than justified if it prevents wastage of financial and human resources not directed to achieving corporate aims.

GENERAL APPROACH OF COST BENEFIT ANALYSIS.

The objective of Cost Benefit Analysis (CBA) is to assist decision making by assigning dollar values to all advantages and disadvantages of the project under investigation.

A comprehensive Cost Benefit Analysis will include identification and quantification of all cost and benefit items including intangible costs and benefits together with any external costs and benefits which relate to groups or individuals outside the organisation. The cost benefit ratio, derived by dividing total benefits by total costs, reflects the relative value of the project.

$$\text{COST BENEFIT RATIO} = \frac{\text{TOTAL BENEFITS}}{\text{TOTAL COSTS}}$$

A cost benefit ratio of 1 or greater indicates that benefits exceed costs, and suggests that the project should proceed.

Partial Cost/Benefit Analysis

Where quantification of intangible benefits is overly difficult or controversial and total costs are known, a partial cost benefit analysis may be undertaken using only tangible benefits. In such cases, a minimum acceptable value for intangible benefits may be derived as shown below.

MINIMUM VALUE OF
INTANGIBLE BENEFITS = TOTAL COSTS - TANGIBLE BENEFITS
FOR PROJECT JUSTIFICATION

Decision makers may then form an opinion as to whether, in their estimation, the value of intangible benefits exceeds this minimum and is therefore sufficient to justify the project.

Discounted Cashflow

As projects generally yield a stream of costs and benefits over time, the value of costs and benefits are discounted back to present values using an appropriate discount rate and standard discounted cashflow formulae. This allows meaningful comparison of costs and benefits which occur at different stages in the life of a project.

Stages in Cost/Benefit Analysis

The stages employed in a cost/benefit approach to project evaluation may be summarised as shown below.

STAGES IN COST/BENEFIT ANALYSIS

- **Project Definition**
- **Identification of Costs and Benefits**
- **Classification of Costs and Benefits**
- **Evaluation of Tangible Costs and Benefits**
- **Evaluation of Intangible Costs and Benefits**
- **Selection of Discount Rate**
- **Evaluation of Cost/Benefit ratio**
- **Sensitivity Analysis**

Each of these stages will now be briefly discussed in relation to GIS implementation projects.

APPLICATION OF COST BENEFIT ANALYSIS TO GIS PROJECTS

Project Definition

Project definition, in relation to the implementation of geographic information systems, may be viewed as a two stage process comprising determination of user requirements and conceptual system design.

Determination of User Requirements

User needs analysis forms the basis of determining optimal system design. The generally adopted approach utilises surveys and questionnaires of key personnel to identify data requirements and information flows within the organisation.

Determination of ultimate user requirements is a difficult task as in involves the anticipation of future business directions, the changing customer focus and some prediction of future technological capabilities.

Conceptual System Design

Once user requirements have been satisfactorily determined the organisation is able to commence conceptual system design. The process of conceptual system design will take into account data storage capacity requirements and preferred system configuration and will involve a choice between mainframe, workstation or personal computer based systems.

Identification and Classification of Costs and Benefits

In applying CBA techniques to GIS implementation projects, identification and classification of costs and benefits follows preliminary system design. Tables 1 summarises cost items which are relevant to the implementation of GIS in a local government context, based on a classification of tangible costs (ie readily quantifiable), or intangible costs.

Tangible Establishment Costs.

The initial cost of hardware and software is readily identifiable, but represents only a proportion of total establishment costs. Data collection and database establishment commonly comprise over 50% of total establishment costs[5].

Tangible operating Costs

Tangible operating costs include hardware and software maintenance, data updating and ongoing staff training. While costs associated with staff training and system management may be difficult to separate from overall departmental operating costs, they can represent a significant cost component and should be included in GIS project evaluation.
Costs associated with staff time may be estimated by establishing an hourly charge based on salary and an on-cost factor which takes into account employment costs such as workers compensation, provision of sick leave and superannuation.

TANGIBLE COSTS

ESTABLISHMENT COSTS
- Feasibility study
- System evaluation and selection
- Hardware
- Software
- Data collation
- Database establishment
- Graphic Data
- System testing
- Consultants fees
- Staff training
- Site costs (provision of office space)
- Administration

OPERATING COSTS
- Hardware maintenance and replacement
- Software maintenance
- Database maintenance
- Graphic data maintenance
- Consultants fees
- Staff training
- Consumable materials
- Site costs (rent on office space)
- Administration

INTANGIBLE COSTS

ESTABLISHMENT COSTS
- Impact of implementation delays
- Disruption of current operations during implementation
- Staff attitudes to organisational change
- Exposure to risks, including
    * failure to obtain expected benefits
    * costs greater than expected
    * development time greater than expected
    * data incompatibility

OPERATING COSTS
- Increased dependence on office equipment reliability
- Increased dependence on key operating staff

Table 1: Costs Associated with GIS Implementation[6]

Intangible Establishment Costs

Introducing new technology in the workplace may have a significant impact on the continued operation of an organisation. Staff may be reluctant to maintain efficiency of existing manual operations if these methods are seen as shortly becoming redundant. Conversely, staff may feel threatened by replacement of traditional work practices with computer technology which may be alien to them. Under these circumstances, a reluctance to accept change can result in reduced productivity in the short term. The disruption to normal activities caused by the introduction of new technology can also increase pressure on staff and may reduce staff morale.

Embarking on any new venture has its associated risks. McDougall[7] suggests that organisations moving into GIS face risks associated with:-

* failure to obtain expected benefits;
* costs greater than expected;
* time taken to development GIS greater than expected; and
* data incompatibility with hardware or software.

In a pre-implementation Cost Benefit Analysis, a value may be placed on these risks by multiplying the estimated probability of occurrence by the cost of failure or rectification.[8]

COST VALUE OF RISK = PROBABILITY X COST OF FAILURE

Evaluation of existing GIS systems would presumably include actual costs resulting from failure in any of the areas noted above, and therefore need not take this intangible cost into account.

Intangible operating Costs

Reliance on computer technology includes a risk associated with equipment failure causing temporary or permanent loss of access. Standard operating procedures, such as data backup and archiving, are available to minimise the risk of total data loss, although it is not possibly to eliminate all insecurity.

In order to exclude this intangible cost item, it would be necessary to assume that the risk of temporary or permanent data loss utilising GIS technology is less than the risk of losing access to existing manual record systems.

Similarly, in the event that implementation of GIS increases reliance on key personnel, there will be an increased risk of losing access should this person be temporarily absent or leave the organisation permanently. This risk may be reduced by establishing a documented set of standard procedures for system operation and database maintenance.

Tangible Benefits

As shown in Table 2, tangible benefits of GIS implementation may be categorised as cost savings or cost avoidance.[9]

TANGIBLE BENEFITS

COST SAVINGS
- Reduction in staff time to carry out functions
- Reduction in overall staff numbers
- Reduction in space requirements for data storage
- Elimination of external data management fees

COST AVOIDANCE
- Increased productivity avoids need for additional staff
- Avoidance of future hard copy data storage and preservation costs (such as micro filming)

INTANGIBLE BENEFITS

INTERNAL BENEFITS
- Improved data accuracy
- Improved information processing efficiency
- Faster access to data
- Faster decision making
- Availability of new/better/more information
- Promotion of organisational learning and understanding
- Improved staff morale

CAPABILITY BENEFITS
- Ability to investigate increased number of alternatives
- More informed decision making
- Improved organisational planning

EXTERNAL BENEFITS
- Improved service to clients
- Improved client perception of the organisation as being technologically progressive

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Table 2: Benefits of GIS Implementation[10]

Cost Savings - What reduction in expenditure has occurred because we now have a GIS?

Cost Avoidance - If we didn't have a GIS what additional expenditure would now be required?

Examples of **cost savings** would include staff time savings and decreased expenditure on external consultants. Maintaining previous staff levels despite an increase in workload would represent **cost avoidance** of additional wages.

Intangible Benefits

Monroe[11] suggests three classifications for intangible benefits of GIS:

(i) **Internal benefits**, such as improved quality of information to support decision making and improved staff morale,

(ii) **Capability Benefits**, which relate to the tasks which can now be undertaken which were not previously feasible, and

(iii) **External Benefits**, such as improved public perception of the organisation as being technologically progressive.

Mechanisms commonly applied to evaluate intangible benefits include shadow pricing and estimating the value of consumer surpluses. In non-rigorous applications of cost/benefit analysis, a minimum value of intangible benefits for project acceptance may be derived by subtracting tangible benefits from total costs as indicated above.

Discount Rate

Costs associated with Geographic Information Systems tend to be lumped near the start of the project, while benefits occur as a stream over the project life.[12] Accordingly, the discount rate utilised to reduce costs and benefits to a common time frame will significantly affect the value of the cost benefit ratio. For this reason sensitivity analysis with respect to discount rate should always be included in evaluation of GIS/LIS projects.

It is suggested that a "real" discount rate (i.e. with inflation component removed) be adopted for reasons of simplicity[13]. Recommended "real" discount rates for sensitivity analysis are 4%, 7% and 10%.

Evaluation of Cost/Benefit ratio

Once values have been derived for all costs and benefits (or, in the case of a partial analysis only tangible costs and benefits), these values are tabulated as they occur in the life of the project. A period of 10 years is commonly adopted as a reasonable time-frame for GIS project life. The Net Present Value (NPV) calculation is then performed to reduce all costs and benefits back to present value dollars. The value of costs and benefits may then be compared, and the Cost/Benefit ratio calculated.

In carrying out Cost Benefit Analysis it is generally necessary to make assumptions which simplify a complicated set of real world variables. The process should therefore be viewed as a tool which supports decision making rather than as a definitive mechanism for project evaluation.[14]

Sensitivity Analysis

In order to test whether a derived cost/benefit ratio is significantly affected by variation of factors such as value of anticipated future benefits, project life or interest rates, the ratio may be re-calculated for various sets of assumptions. This process is referred to as sensitivity analysis. It is strongly recommended that, at a minimum, sensitivity analysis be carried out with respect to project life and discount rate.

Projects which yield a cost/benefit ratio in excess of unity for all sets of assumptions can obviously be approached with more confidence.

LOCAL GOVERNMENT GIS IMPLEMENTATION PROJECTS

Local Government applications of GIS may be categorised as either administrative or analytical.

GIS APPLICATIONS

ADMINISTRATIVE	ANALYTICAL
(Management of property information)	(computer modelling)

While administrative applications facilitate streamlined access to property information, advanced analytical capabilities of geographic information systems provide local government planners with the ability to construct comprehensive computer models of existing urban or rural environments. Although these analytical capabilities offer planners a powerful tool which may be utilised to model the outcome of planning decisions, it would appear that current local government GIS applications focus primarily upon management of property information for administrative purposes.

Warringah Shire Council is yet to implement a geographic information system for property data management, however a needs analysis carried out in 1990 suggests that areas of existing duplication may be eliminated by the introduction of GIS technology.

Some two years ago Yarrowlumla Shire Council implemented a personal computer based geographic information system which now provides streamlined access to a range of parcel based property information.

The experiences of these two organisations will now be briefly discussed in relation to the general project definition and cost/benefit analysis techniques outlined above.

WARRINGAH SHIRE COUNCIL - NEEDS ANALYSIS

Warringah Shire Council, located on Sydney's northern beaches, was selected in 1990 for independent user needs analysis in connection with an undergraduate project within the School of Surveying, University of NSW[15]. Council was, at that time, evaluating options for the development of a land information system to support corporate information management.

Prior to 1989 council had conducted a survey of internal information availability. This survey took the form of an inventory which determined the location and format of computerised and hard copy information storage. Results of this survey were adopted as a logical basis for the development of a user needs analysis.

The explicit use of maps by each department within council was examined to determine the requirements for use of graphic data. Figure 1 shows the location of information stored in plan form held by the Town Planning, Property, Engineering and Health and Building departments. The relationship between the data requirements of these departments is shown in Table 3. It can be seen that a range of information categories are needed by all four departments. Seven forms of information were required by all departments within the Council, comprising

* Property/Rate Details,
* Mapping/Land Use Base,
* Council Policies and Resolutions,
* Statutory Affectations,
* Servicing Details,
* Easement Register, and
* Council Owned Land.

It is apparent that of these seven categories, five involve the use of graphical information, and a combination of all seven would form a comprehensive base for any land information system.

The user needs survey also determined time spent using maps and any overlap in map storage between departments. One factor that was found to be difficult to gauge was actual time spent by Council employees using and upkeeping maps. For example, all staff in the town planning and engineering departments use maps to varying degrees throughout the day. The survey evaluated departmental map use in terms of the total number of people in each department and average time spent using and upkeeping maps. It was found that a total of 13000 hours was spent per year throughout the organisation using and maintaining graphical information.[16]

Table 3 also shows that the property register set of maps is required by at least three of the four departments. In addition, all departments store the 1 : 4000 series of plans. There is therefore significant duplication in terms of use, storage and maintenance of maps. Having identified departmental needs for graphic and textual data, Council's next task will be development of a conceptual system design. Following this stage, Council will be in a position to evaluate costs and benefits that will result from implementation of a geographic information system for property data management.

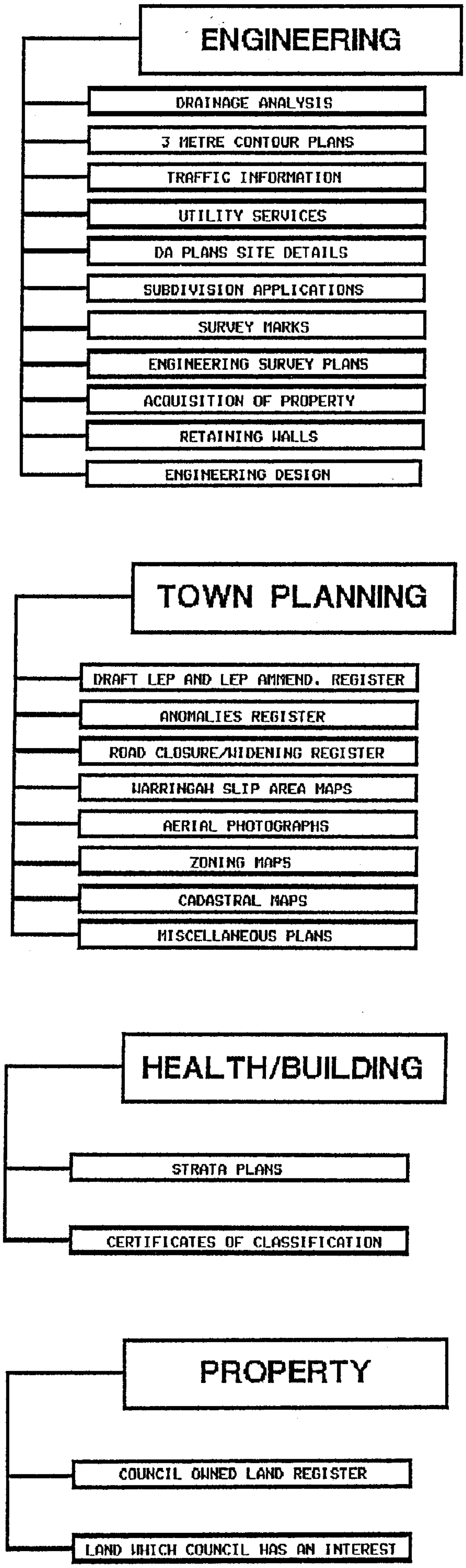

Figure 1: **Warringah Shire Council - Graphic Data Storage**

CATEGORY	TOWN PLANNING DEPARTMENT	PROPERTY DEPARTMENT	ENGINEERING DEPARTMENT	HEALTH AND BUILDING DEPARTMENT
Property Rate/Details	x	x	x	x
Mapping/Land Use Base	x	x	x	x
Council Policies and Resolutions	x	x	x	x
Devel. Applications	x		x	x
Development Consent Register	x		x	x
Statutory Affectation	x	x	x	x
Legal Case History Register	x			
Section 149 Certificates	x		x	
Record of Dev't Approval	x		x	x
Services Details	x	x	x	x
Site Disposal/Acquisition	x	x	x	
Section 94 Contributions	x	x	x	
Slip Areas	x		x	
Aboriginal Grants	x		x	x
Heritage Records	x			
Tree Removal History	x		x	x
Coastal Management Matters	x		x	
Road Register	x		x	x
Pipeline Register			x	
Watercourses and Catchments	x		x	
Flood Areas	x		x	x
Drainage Easement Register	x	x	x	x
Land Zoning	x		x	
Land Capability	x		x	
Vegetation Type	x		x	
Vegetation Cover	x		x	
Soil Type	x		x	
Slope	x		x	
Pavement Management			x	
Council Owned Land	x	x	x	x
Parks and Reserves		x	x	x
Notices (Health etc)				x
Septic Tank Approval			x	x
Licences		x	x	x
Certificates of Classification (Building)				x
Building Certificates				x
Subdivision Application	x		x	x
Survey Data			x	x
Engineering Design			x	
Works Scheduling			x	x

Table 3: Tabular Representation of User Needs

YARROWLUMLA SHIRE GIS IMPLEMENTATION.

Introduction

Yarrowlumla Shire is located on the Southern Tablelands of New South Wales and has a land area of 2987 sq. kilometres. The Shire is predominantly rural in nature and includes the minor settlements of Bungendore, Sutton, Michelago and Captains Flat, comprising a total of some 6000 land parcels.

In order to more efficiently cope with an increased level of development activity and to fulfil council's information provision obligations under section 149 of the Environmental Planning and Assessment Act, a decision was made in 1987 to implement a parcel based land information system.

The system ultimately installed by Yarrowlumla's planning department utilises the LGAbase software running on a Compaq 386 series personal computer. LGAbase comprises a number of compiled dBase III programs which interface with the Intergraph Microstation PC CAD[17] Software.

Cost/Benefit Analysis

The experiences of Yarrowlumla Shire will now be used to illustrate the application of CBA techniques to GIS/LIS implementation projects[18]. It should be noted that the following analysis was undertaken after GIS implementation. While this allows accurate evaluation of implementation costs, benefits derived from savings in staff time are based on estimates of "before" and "after" staff time required for various tasks. Although somewhat trivial because of the small scale nature of the project, the following analysis does serve to illustrate some of the techniques discussed above.

Cost Items

Costs associated with the implementation and operation of the Yarrowlumla Shire geographic information system are listed in Tables 4 and 5 respectively.

In order to quantify costs associated with internal staff labour, hourly rates are derived using the formula stated above, allowing 30% as a reasonable on-cost to salaries to cover items such as workers compensation, sick leave, superannuation, rent for floor space etc. It should be noted that data capture was the major cost component of GIS establishment.

Tangible Costs Item	Source[19]	Hours	Rate	Cost
Feasibility Study	E	24	$40	$960
System Evaluation & Selection	E	38	$40	$1,520
Hardware	A			$15,700
Software	A			$9,600
Data Collation	A	480	$23	$11,040
Database Establishment	A	288	$30	$8,640
Graphic Data	A			$32,000
System Testing	E	40	$23	$920
Consultants Fees				Nil
Staff Training	A	48	$23	$1,104
Site Costs				Nil
Administration	E	40	$40	$1,600
Total				$83,084

Table 4: Yarrowlumla Shire - GIS Implementation Costs

In the case of Yarrowlumla Shire, an assumption is made that the value of intangible costs is negligible. Given the high degree of motivation among staff to implement a new system, staff morale was improved rather than reduced. Much of the data entry was carried out during overtime and consequently disruption to councils normal activities was minimised.

Tangible Costs Item	Source[20]	Hours	Rate	Cost
Hardware Maintenance	E			$1,500
Software Maintenance	E			$800
Database Maintenance	A	120	$23	$2,760
Graphic Data Maintenance	E	40	$23	$920
Consultants fees	A			$3,000
Staff Training	E	40	$23	$920
consumable materials	E			$500
Interest	E			$2,700
Site Costs				Nil
Administration	E	40	$40	$1,600
Total				$14,700

Table 5: Yarrowlumla Shire - GIS Annual Operating Costs

Tangible Benefits

The major quantifiable benefit of GIS implementation is savings in staff time resulting from quicker access to property data. The value of this benefit is calculated using hourly rates for staff time derived above. Based on interviews with planning staff, average time savings in carrying out three common functions utilising GIS were estimated as shown below:

FUNCTION	AVERAGE TIME SAVING
Preparation of 149 Certificates[21]	1 Hour
Processing Development Applications	1 Hour
Respond to property enquiry	15 Minutes

Records kept by councils planning department indicate that an average 250 Development Applications together with 450 Section 149 certificates are processed annually. Property enquiries were estimated to average 6 per working day. The annual value of cost savings calculated on this basis is shown in Table 6.

Annual Cost Savings

	Time saving per unit(hrs)	Annual units	Annual time saving	Rate ($/h)	Annual cost Saving
Reductions in Staff Time					
149 Certificates	1	450	450	$23	$10,350
DA Processing	1	250	250	$23	$5,750
Property enquiry	0.25	1440	360	$23	$8,280
Reduction in Staff numbers					Nil
Reduction in space requirements					Nil
Elimination of External Costs (E)					$5,000
Total Annual Cost Savings					$29,380

Table 6: Yarrowlumla Shire - GIS Benefits

In addition to providing staff time savings, Yarrowlumla's GIS is also capable of producing maps for planning purposes. Planning staff anticipate that this facility will allow external costs for map production to be reduced. The value of this benefit is estimated at $5,000 annually.

Intangible Benefits.

Staff time savings have translated into significantly improvement services to clients. Section 149 Certificates are now available overnight, rather than in two weeks as was previously the case. This dramatic improvement in processing time is due to the elimination of "dead" time between processing stages which was unavoidable under the previous manual system. Having all property data at one central location has eliminated the need for multiple handling of an application.

In order to place a value on benefits resulting from improved service to customers, the value "consumer surplus" generated by these improvements could be estimated. If a period of two weeks is normally required for issue of 149 certificates, the additional fee customers would be prepared to pay for an overnight service represents the minimum value of this benefit. This cost could be estimated by conducting interviews with council's clients.

For the purpose of the current exercise, no initial estimates are provided for the value of intangible benefits.

Cost Benefit Analysis

From a perusal of Tables 5 and 6 is apparent that much of the time saved by utilising GIS technology for productive functions is spent maintaining and updating graphic and attribute data files. In this way time savings are partly balanced out by the additional time required to maintain the system. There is, however, a net annual time saving.
Before comparing the value of costs and benefits, it is necessary to make a number of assumptions:

1. Project life will be 10 years
2. Annual operating costs will continue at 1989 levels
3. Annual cost savings will continue at 1989 levels

Based on these assumptions, Table 7 compares the net present value of tangible costs and benefits which will occur over the anticipated life of the project. Note that all values are stated in 1989 dollars.

YEAR	DISCOUNT RATE	TANGIBLE COSTS	TANGIBLE BENEFITS
0		$83,084	$0
1		$14,700	$29,380
2		$14,700	$29,380
3		$14,700	$29,380
4		$14,700	$29,380
5		$14,700	$29,380
6		$14,700	$29,380
7		$14,700	$29,380
8		$14,700	$29,380
9		$14,700	$29,380
10		$14,700	$29,380
NPV (a)	4%	$194,533	$229,133
NPV (a)	7%	$174,141	$192,853
NPV (a)	10%	$157,645	$164,116
COST/BENEFIT RATIO			
1.18	4%		
1.11	7%		
1.04	10%		

(a) Net Present Value

Table 7: Yarrowlumla Shire - Calculation of Cost/benefit Ratio

The calculation yields a Cost/Benefit ratio in excess of 1 for all three discount rates adopted. On the basis of this analysis, the project is justified even without taking intangible benefits into account. As intangible costs are assumed to be negligible, inclusion of intangible items would significantly improve the derived cost benefit ratio.

Limitations of the Method

Unavoidably, cost benefit analysis will involve some degree of simplification. In the above example, savings in staff time have been estimated on the basis of limited staff interviews, and would be more reliable if supported by a thorough analysis of staff functions before and after GIS implementation. In addition, further analysis would be required to validate the assumption that intangible costs have been negligible.

CONCLUSIONS

The last two decades have seen fundamental changes in the nature and structure of the work environment. Individuals and the organisations within which they function are increasingly subject to rapid change and greater complexity and uncertainty. The availability of new technologies has been a major dynamic in this process of change.

While new technology and technical processes contribute to complexity and uncertainty at an individual level, they offer organisations a potential capacity to respond more quickly to changing economic and political environments. This is particularly true of Geographic information systems. The experiences of Yarrowlumla Shire indicate that long term benefits of GIS implementation include increased flexibility and capacity in the face of increased demands on the organisation. These benefits are not achieved without significant up-front financial investment and short term organisational dislocation.

Qualifications of Analysis.

In order to more fully assess the impact of GIS technology in a local government context it would be necessary to adopt an organisation-wide approach to the evaluation of costs and benefits.

Further research is also required to develop techniques for the evaluation of intangible costs and benefits associated with the use of Geographic Information Systems. Such research will also need to address the economic implications of organisational changes which invariably accompany the introduction of GIS technology.

Advantages of Cost Benefit Analysis

In addition to providing a sound financial basis for project evaluation, we have seen that comprehensive Cost/benefit analysis of GIS implementation projects provide a number of organisational benefits:-

* Developing a meaningful basis for decision making assists in crystallising project objectives, and provides clear project direction at the outset.

* Organisational costs and benefits are identified prior to the commitment of resources. This provides verification that project objectives are realistic in terms of the available financial and manpower resources.

* Staff involvement necessary in the CBA process provides a vehicle for gaining both high level and broad based organisational commitment to the project.

Concluding Comments

On the basis of the limited analysis undertaken in this paper, it may be concluded that Geographic Information Systems do have potential to provide cost effective solutions to the information management requirements of local government. Geographic Information Systems, however, will not perform miracles. The extent to which organisations ultimately benefit from GIS technology will depend principally on the effectiveness of corporate management and on the imagination, ability and dedication of individual staff members associated with system establishment and operation.

In returning to Kirsner's statement regarding the distinction between means and ends, we suggest that Cost Benefit Analysis prior to project implementation is an appropriate mechanism to ensure that playing computer games does not become an end in itself.

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2. Cowen suggests that:
   "The ability to both synthesise existing layers of geographical data and update a database of spatial entities is the key to a functional definition of a GIS".
   (See note 3)

   For the purposes of this present research, the definition of GIS provided by the U.S. Federal Interagency Co-ordinating Committee on Digital Cartography will be adopted:
   "GIS is a computer hardware and software system designed to collect, manage, manipulate, analyze and display spatially referenced data." (See note 4)

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   U.S. Department of the Interior
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5. See, for example
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6. Adapted from PlanGraphics Inc, 1989;
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7. McDougall, 1989, pp 133

8. Barber, G. G., Wake, G. W., and Hutchinson, R. G.,
"GIS - The Alcoa Experience"
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16. Chesher, K. C. (1990)
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17. Computer Aided Drafting

18. Laybutt, P.M. (1990)
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19. Source of cost data: A - Actual, E - Estimated

20. Source of cost data: A - Actual, E - Estimated

21. Under Section 149 of the Environmental Planning and Assessment Act, 1979, Local Councils in NSW are required to provide a Certificate for any land parcel under their jurisdiction indicating planning restrictions applicable to that parcel.

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MICRO-ECONOMIC REFORM, LAND ADMINISTRATION,

and

LAND INFORMATION MANAGEMENT.

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Abstract

In order to ensure its competitiveness an organisation's management has a responsibility to ensure that the ever increasing volume of data collected is transformed into data relevant to the organisation's mission.

Australian land administration systems are costly and many are a continuation of systems established well over 100 years ago. Outputs from these systems support an increasing number of environmental, economic, and resource management systems.

The concepts involved in dealing with information as an economic resource are not well understood by management at large, and comfort is often found in automating historical procedures. As a consequence, expected economic gains may not be realised. There is a need to review the fundamentals of these systems in the light of mission, needs and information management.

Suggestions are offered towards ensuring land administration and information systems migrate towards optimum economic efficiency.

Data and Information

In general terms, when one is looking to change from a paper based system to a computer based one there are three broad options:

1. automate the existing
2. streamline the existing
3. change the existing

The first has the advantage that, organisationally, little or nothing is changed. The disadvantage is that non effective practices will be continued.

The second has the advantage that all the obvious and easy problems are addressed but that some potentially major non effective practices are not addressed.

The third has the following advantages:-

a) the ability to asses the relevance of current processes to the organisation's fundamental mission
b) the ability to carry out measurements of efficiency and effectiveness
c) the ability to design an appropriate computer bases system based on the findings of a) and b)

The major disadvantage is that, for a large organisation (which most land administrations are) this will take significant time. It will also involve much uncertainty as to the future employment and organisatoinal roles with all the attendant problems this brings.

In general, the rationale for investment in computers in the 1960's was the automation of data handling of existing processes. This was so successful in its impact that, on the whole, there is no shortage of data.

The ability to access this data effectively is in question. Some of the existing data banks might better be termed "data cemeteries". Paul Tom(1988) has said that by the time our children graduate from high school the amount of 'data' in the world will be four times greater than now. A good example is the routine collection of Landsat and SPOT data and the large amount of this that is unused simply because we are unable to cope with the volume of data.

The organisational emphasis should now be shifting to how this data should be turned into the information needed for social progress. Information is seen as an increasingly important factor in production, with some commentators suggesting that it is no longer appropriate to consider information as simply a fourth factor in production, (the others being matter, energy, and labour).

Picot (1989) considers that information has become the prime production factor, and the purpose of information management is to make sure it is put to good use at both strategic and operational levels.

Information Technology and Information Management

Information management is the process of managing information content. This is a business issue and involves understanding the needs, use, and value of information in the organisation.

Information technology involves the design and management of the technological infrastrucutre of the organisation. Olaisen (1970) says that in the '60's this function was seen to be the source of competitive advantage, but that this is now rapidly moving to the management of information.

The role of information technology has always been to help organizations solve critical business problems or to deliver new services. This involved collecting data, turning that data into information, and turning the information into knowledge quickly enough to reflect the time value of knowledge.

Over the last 30 years, much of our money and energy has focused on the first stage of the process -- building hardware, software, and networks powerful enough to generate useful data. That challenge is close to being solved; we have gotten our arms around the data-gathering conundrum.

Hopper (1990) considers that the next stage, and the next arena for competitive differentiation, revolves around the intensification of analysis and that astute managers will shift their attention from systems to information.

However it is believed that there needs to be a much clearer differentiation between the terms 'information technology' and 'information management', because many Australian managers use the terms interchangeably.

Information, Management and Economics

The nature of information as an economic resource is not well understood and will, consequently, be the focus of a lot of attention in the next decade. The Australian Federal Parliament has already acknowledged this problem and has an all-party committee (The Jones Committee - Australia in an Information Economy) examining the issue. It is due to report about mid-1991.

Because of the factors and trends outlined above, it is becoming increasingly important to ensure that the information bases of all organisations are not only managed efficiently and effectively, but also match the mission of those organisations.

This is a responsibility of management in all sectors of the economy. At a macro level it will be a major determinant of the competitiveness of nations. Australian organisations, from the Federal Parliament through to individual households, will be affected by these trends.

We suspect that most of this audience will be engaged in some aspect of information technology ranging from its management to a variety of system specialists. It is pertinent to point out that organisational management will need your assistance in redefining the management paradigm of the 1990's, particularly in the management of Australia's land information.

Management will need to consider how the large amounts of land related data which a number of agencies hold, collect and update is to be used efficently and effectively. As an economic resource it must benefit not only the historical and current custodian of the data but also the Australian community at large.

To not address this issue , or to give advice which is not genuinely directed towards overall economic efficiency and effectiveness, is to seriously damage the reform processes that Australia is presently undertaking.

Land Administration and Micro Economic Reform

The Changing Need

We believe that today's Australian land administration systems are still largely based on the needs and processes established well over a century ago. They now support bureaucracies of many thousands of people across the country. Historically land administration was concerned with the recording of boundaries and rights to land as Australia was "opened up". The political objective of the day was productivity from the land. To do this allocating the land was necessary. Lands departments were the instruments of the allocation and recording.

Present systems were designed when their primary objective was to provide a secure tenure for land owners. To assist the primary producers to achieve maximum productivity government departments of primary industry were established.

These groups have, over the last 50-100 years, carried out their mandate very well and developed large organisations, gathered large amounts of data to support their various activities and have become, like most large and old organisations, institutionalised.

We contend that the needs of today and the political drive has changed from one of the opening up of large tracts of rural land, establishing tenure and obtaining maximum productivity to sustainablle development of the land. There is no longer any significant opening up of land but basically only small scale subdivisions in the urban environment.

In a state where the limits to the availability of land as a resource in this process are becoming more obvious an increasing number of private and public agencies have begun using land related data for purposes related to sustainable development and the management of an increasingly complex society. Eventually secure tenure, whilst remaining an important part of these systems, may become a minor use.

If one accepts that the environment which gave rise to these systems has long gone, then the following types of questions can be asked:-

- is the legacy of organisational mission still valid?
- are the processes it carries out still relevant?
- does the data that is collected support the needs?
- is the data transformed into information which supports today's needs and decision making?

We believe that the answer to these questions lies more in the negative than the positive. One of the problems is the lack of objective and available data. To the authors' knowledge no significent work has been done in Australia. We are aware of the various reorganisations that have occured in Lands type departments around the country but believe this is more "streamlining the existing " under external pressure, rather than building a support organisation which addresses the need for land related information to assist sustainable development and other complex needs of today's society.

One of the problems of having the temerity to question the effectiveness of long established systems and organisations is that they can be conceived as a personal attack on the people and the organisation and they react accordingly. We would ask that this be treated as an exercise in logic.

The Cost of the Present System of Land Administration

The cost of the present system is not readily apparent. The authors have heard of figures of C$60/head of population /year mentioned for the Canadian system. One of the problems is also how to define land administration for the purpose of establishing costs.

To obtain some "ball park" figures a group of postgraduate students with Professor Lyons extracted some figures from the Queensland state government 1990-1991 budget papers. The table below shows the results.

	COSTS			
	Total $M	$/HOP	$/IE	$/POL
tenure admin.	38.7	14.9	44.5	21.5
valuation	25.1	9.7	28.9	13.9
inventory	19.9	7.7	22.8	11.1
	83.7	**32.3**	**96.2**	**46.5**
land use . plan/zone	84.9	32.8	97.6	47.2
. environment	117.4	45.3	134.9	65.2
	202.3	**78.1**	**232.5**	**112.4**
Total	**286.0**	**110.4**	**328.7**	**158.9**

Notes

1. HOP = head of population. taken as 2.59M (1986 census)
2. IE = income earner. taken as 0.87M (1986 census)
3. POL = parcels of land. taken as 1.8M
4. tenure admin = tenure administration. Figures for those departments involved in the registration, recording, examining of some form of tenure or rights.
5. valuation is that function which provides the base for forms of tax based on land
6. inventory is the aspect that deals with recording the topography. Geological maps are included and also information based products. Information and maps from the Department of Primary Industries is not included
7. planning and zoning includes policy and also the natural as well as the built environment.
8. environment includes allocation from a number of departments for a variety of programs.
9. no figures have been included for departments involved in land productivity.

The above figures represent annual appropriation and hence the figures are below the real cost. No allowance has been made for buildings and infrastructure, normal overheads etc. Also only the major state departments have been included. There are many others in the chain and, even though only small, cumulatively mount up. No allowance has been made for the cost incurred by local governments. There are approx 137 in Queensland and a significant part of their activities is some form of "land administration".

In the absence of figures from other states in Australia and overseas and as there is no known standard ie OECD for establishing cost bench marks, it is not possible to draw comparisons or firm conclusions.

However, it is obvious that it is not cheap and one would be surprised if significant improvements and, hence reductions in cost, could not be achieved both in the short, as well as the long term.

There is a school of thought which believes that the Australian system of land administration is very good and can be exported as is to less developed countries. Several years ago the authors were fortunate enough to discuss the economics of land administration systems with Harold Dunkerly, now a retired economist from the World Bank. He informed us that the cost of land administration in Australia and in similar Western countries limited its usefulness in less developed countries, as the cost often exceeds the per-capita income of those countries.

There seems to be a reluctance to subject land administration systems to objective economic scrutiny. We submit that they would not survive such a scrutiny, and that while this condition remains, they will remain an unnecessary burden on the cost of public infrastructure in this country.

Some Thoughts

As a basis for the ongoing reform of the management of land related information in Australia, it is essential that economic baselines be established. This will require a commitment to undertake the objective research necessary to determine the true economic cost of these systems. We cannot think of any more important subject in Australia for research at this time. Researchers are free to quote this in their bids for research funding.

It is time to reexamine and redefine the objectives of land information systems in Australia, to develop a land information model which is optimized to ALL users and likely users, and is seen as one of the many systems underpinning the growth and management of the state.

It is important to involve other users in the reform process. For example, at conferences such as this, we should increasingly involve spokespersons from other industries dependent on existing land information systems. We should ensure their needs continue to be met. We should also involve those who will be the new users of the future. Full advantage should be taken of the support available from multi-skilled land information organisations, such as AURISA.

The technological revolution is creating "... new possibilities for extending and sharing access to information, making possible new kinds of organizations. Big companies will enjoy the benefits of scale without the burdens of bureaucracy. Information technology will drive the transition from corporate hierarchies to networks. Companies will become collections of experts who form teams to solve specific business problems and then disband. Information technology will blur distinctions between centralization and decentralization." Hopper (1990). Unless our custodians of land information systems recognise and move to take advantage of these developments, future generations of Australians will continue to be burdened with unnecessary infrastructure costs.

One could argue that during the last 150 years in Australia the emphasis has been on building the physical infrastructure of roads, dams, etc, and that the current challenge is to build the information infrastructure.

A modern land register should become a vital component of the nation's information infrastructure as it is basic to virtually hundreds of other systems which rely on the cadastral model for the spatial integrity of their systems. It should take account of technological opportunities to provide a register which is available to all people entitled to access it, without delay and no matter where they are in the relevent state.

Land information should also be made available at cost of extraction only. Moves to strike a pricing policy based on what the market will bear will aggravate social divisiveness into those groups who are information-rich and those who are information-poor. Equity in access to information does not feature highly in the agenda of land information conferences such as this. (O'Brien, 1989)

There is little doubt that the employment needs of an efficient LIS model would be significantly less than is presently the case. Planning should address the retraining and redeployment of those workers into the process of information analysis, a by-product of land information which has never seriously been addressed due to inadequate resources.

Land information workers also need a far greater understanding of their role in a system, **and now its over to you !**

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TOWARDS A NATIONAL PERSPECTIVE FOR LAND INFORMATION MANAGEMENT - SOME IMPORTANT ISSUES

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ABSTRACT

Land Information Management (LIM) is experiencing an upsurge in interest at all levels of government and within the private sector. There is also an increasing awareness of the benefits of LIM for resource managers.

The Australian Land Information Council (ALIC), since its formation in 1986 as the peak intergovernmental Council, has played a significant role for co-operation and co-ordination in LIM in Australia and New Zealand.

ALIC has developed a National Strategy on Land Information Management and an Action Plan for implementation. ALIC is providing leadership and a direction for LIM in Australia and New Zealand.

However, we as LIM practitioners must remember that land information is not an end in itself but a tool, albeit a very valuable one, for use by all resource managers.

INTRODUCTION

The Conference on Land Information Management (LIM) is occurring at a time when there is a considerable upsurge in interest in land information generally. This interest is being demonstrated not only by the long standing proponents of land information systems (LIS) and geographic information systems (GIS), but at very senior levels in governments and by the private sector. A practical example of the increasing interest is shown in the prediction that LIS/GIS systems are expected to be the fastest growing area of computer technology over the next ten years, with expenditure of approximately $A100 billion in the Western world. Australia is expected to spend between $A100m and $A200m during the next ten years, whilst New South Wales itself is expected to contribute well over half of that amount.

Given the significant increase in interest flowing from an awareness of the benefits of land information systems for resource managers and their potential revenue generation, the need for more effective building and management of these systems is becoming paramount. I have had the dual advantage of being both a provider of land information systems, through my Department's Land Information Centre at Bathurst, and at the same time a LIS user through our Land Management Division and the Western Lands Commission. Some LIM co-ordination activities have been taking place in Australia for some years and I will now cover some of these.

HISTORY AND BACKGROUND OF THE AUSTRALIAN LAND INFORMATION COUNCIL (ALIC)

During the 1970's and 1980's, government agencies in all jurisdiction in Australia and New Zealand were building and upgrading their land information databases for their own needs, with little co-operation within States/Territories or nationally, although LIS managers were exchanging ideas and sometimes meeting informally.

In 1984, following a National conference in Adelaide, "Better Land Related Information for Policy Decisions", the need for a national focus was acknowledged and a principle recommendation was for a peak national council. Following endorsement by the Prime Minister, State Premiers and the Chief Minister of the Northern Territory, ALIC was formed and first met in 1986.

Council members are generally the chairpersons of LIS steering committees/councils in each State and Territory. New Zealand, the Commonwealth Government (AUSLIG) and the Australian Defence Forces are also represented on ALIC.

ALIC is assisted by the Australasian Advisory Committee on Land Information (AACLI), which consists of heads of land information co-ordination units in the same jurisdictions as ALIC members.

Role and Functions of ALIC

ALIC is the peak inter-governmental body on land information, whose ***mission*** (as recently revised) is "to provide leadership for effective management and use of land information in the interests of the Nation by:

. addressing land information at the national level;

. supporting the development and implementation of national land information management guidelines and standards; and

. providing a national forum for sharing of experiences and exchange of information on land information management at the policy level."

ALIC's new ***objectives*** are:

". to promote better land information management, its uses and benefits;

. to ensure that education and training in land information management appropriate to industry's needs are available;

. to establish a national directory of land information;

- to take the lead in the development of data standards for land information management;

- to investigate national priorities for the acquisition of basic land related data and encourage the integration of national priorities with jurisdictional production programs;

- to promote Australasian expertise in land information management in the overseas market place;

- to support research and development of technology relevant to land information management."

ALIC's ACHIEVEMENTS IN LIM

National Strategy on LIM

Probably the most significant achievement of ALIC to date, apart from it providing an on-going forum for national co-ordination, is the formulation of a National Strategy on LIM. The first edition was comprehensively revised following two workshops on natural resources data management (referred to below); to include further issues such as education, training and employment classifications; and to include an Action Plan to enable ALIC to effectively achieve objectives for national co-ordination. AACLI has also prepared a reporting system for the Action Plan which will allow ALIC to gauge progress on implementation and to re-assess priorities as required.

The Strategy contains ten key issues grouped into three related areas which are as follows:

- **Developing the Administrative and Political Environment**
  Item 1 : Breaking down the Barriers
  Item 2 : Land Information and People
  Item 3 : Knowing its Value
  Item 4 : The Land Information Industry
  Item 5 : Providing the People

- **Establishing the Operational Framework for Effective Land Information Management**
  Item 6 : Getting it Right
  Item 7 : Knowing What's There
  Item 8 : Managing the Land Information Resource

- **Maximising the Benefits to the Nation**
  Item 9 : Making Land Information Systems Work
  Item 10 : Reaping the Benefits

National Resource Data Workshops

ALIC perceived a need to broaden the scope of its responsibilities and to ensure that natural resource data management issues are addressed at a national level. In several member States and Territories, representatives from natural resource management agencies have been included in jurisdictional peak councils or sub-committees have been formed to ensure the inclusion of resource data as layers of an integrated LIS.

ALIC also convened two workshops on National Co-ordination of Natural Resources Data in 1989 and 1991. A list of recommendations from the second workshop is attached as Appendix A.

Publication of Issues Papers on LIM

As part of its active program of disseminating information on LIM and to promote national co-ordination, ALIC released during 1990 four Issues in LIM papers as part of an on-going series. These papers are:

- *Paper No. 1*
  Custodianship/Trusteeship
  Outlines the criteria for selecting custodianship agencies for core data items in a LIS and their responsibilities.

- *Paper No. 2*
  Charging for Land Information
  Outlines the principles of charging for land information and considers some pricing strategies for current and new types of products.

- *Paper No. 3*
  A General Guide to Copyright, Royalties and Data Use Agreements
  Provides guidance to understand the issues of copyright as it effects computer based material and deals with data use agreements.

- *Paper No. 4*
  Access to Government Land Information - Commercialisation or Public Benefit?
  Discusses the case for commercialisation of government land information and the case for public benefit considerations.

Data Standards

ALIC has developed a close working relationship with Standards Australia on data standards for LIM and has referred three standards to Standards Australia. These are:

- Land Use Coding
- Street Addressing
- Australian Spatial Data Transfer Standard (SDTS)

ALIC has committed $100,000 per annum towards a support group for an Australian SDTS.

Glossary of Terms

ALIC has undertaken under its National Strategy on LIM (Objective No.1) to produce a Glossary of Terms to replace the now out-of-date AURISA Glossary and to cover gaps in overseas glossaries which have proved unsuitable for Australian and New Zealand purposes. AURISA has been invited to participate in the revision and the private sector and educational institutions will be involved.

ALIC's FUTURE DIRECTIONS IN LIM

Increased Co-ordination in LIM

ALIC will continue to carry out its current programs in national co-ordination and co-operation and will seek to focus on a broader range of issues, some of which are mentioned below, e.g. natural resources data. ALIC has also established contact with other organisations in the LIM field including:

- liaison with the Inter-Governmental Advisory Committee on Surveying and Mapping (IGACSM);
- agreed to exchange work programs with the Australian Surveying and Mapping Industries Council (ASMIC) and to support its proposed Education Review;
- established contact with Ministerial Councils including the Council of Nature Conservation Ministers(CONCM);
- agreed to support appropriate projects of educational and research organisations including key centres such as the Australian Key Centre in Land Information Studies in Queensland (AKLIS).

Natural Resources Data

ALIC has resolved to continue its support for the collection and integration of natural resource and environmental data through implementation of its National Strategy on LIM and recommendations of the second National Workshop on Natural Resources Data Management. The formation and work of the Resources Assessment Commission at the national level and the increase in resource management investigations and committees of inquiry at jurisdictional level have clearly focussed on the essentiality of land data as a basis for environmental protection and management strategies.

Work is proceeding on establishing natural resources data inventories at State/Territory levels and ALIC and its members have been negotiating with the National Resources Information Centre (NRIC) on a proposed national directory.

Special Premiers' Conference

Following the Conference between the Prime Minister and State Premiers in October, 1990, working groups of Commonwealth and State/Territory officials were established to investigate and formulate draft agreements in specified areas, including a Working Group on Environmental Policy. One of the first tasks of this Group is to develop a draft "Intergovernmental Agreement on the Environment" for consideration at the November, 1991 Special Premiers' Conference. ALIC has been identified as having a co-ordinating role in the development of standards and the facilitation of land information collection and handling.

Land Information/Land Management Ministers' Forum

The November, 1990 meeting of ALIC recommended that Ministers in Australia and New Zealand with responsibilities for LIM and land management generally should meet to discuss common issues of national and international significance. The Forum is scheduled to take place in New Zealand in November, 1991 to coincide with a number of other land information and land administration meetings/conferences. This Forum will allow Minister's to consider and formulate policies in areas such as LIM, micro-economic reform, resource assessment and management, defence and national security, environmental protection, revenue generation, etc.

Data Standards

ALIC is committed to continuing its drive for formulation and implementation on standards for land data, including land use coding, street addressing and an Australian Spatial Data Transfer Standard as mentioned previously. ALIC will provide initial funding for this work for the next three years with review and possible extension.

Role of the Private Sector in LIM

A number of agencies in States and Territories are examining or are negotiating with private sector operators in relation to land information. There has been widespread consensus on the need for involvement of the private sector in different stages of the building of systems, from systems development and data capture through to final marketing of information. In New South Wales, we are negotiating for the development and operation of an on-line Public Enquiry Service for the integrated data which exists in the State LIS Hub. When initial Expressions of Interest were called for there were twenty three respondents, which shows the level of awareness of LIM in the private sector.

In the Department of Lands, Land Information Centre (LIC) at Bathurst, a similar call for private sector involvement in 1989, led to some sixty four proposals. This has resulted in a number of joint ventures in the survey, mapping and land information areas and particularly the development of a data capture capability in the private sector, which had been largely non-existent.

Overseas Consultancies

Australia is establishing itself as a world leader in LIM and our expertise and experience is being demonstrated internationally, especially in South East Asia. Many jurisdictions are involved in joint ventures with private sector and academic partners. ALIC has undertaken to co-ordinate projects across jurisdictions and is advocating an integrated Australian approach to bidding for overseas projects, rather than a parochial State or Territory approach.

Education and Training

There is widespread recognition in *Australia and New Zealand* of the shortage of people with skills in LIM. To address this ALIC has established an objective within its National Strategy on LIM to ensure that the education and training needs of government and the private sector are quantified and are being met. This will involve liaison with industry and educational/training institutions.

CONCLUSIONS

As outlined above, LIM has reached a very important stage in its development, and a very satisfying one for its early proponents. There is now a clearly demonstrated upsurge in interest in LIM and an increasing awareness in resource management agencies of the importance of land data. LIM should underpin all important resources and infrastructure decisions, whether they be in environmental protection, land use planning, development, infrastructure provision, etc. It is interesting to note that the proponents of the Very Fast Train (VFT) Project recognised the need for LIM to assist in the feasibility study for this very large scale venture.

However, it must be remembered that land information is not an end in itself, but only a tool, albeit a very valuable one, for all resource managers. As LIM practitioners, it is necessary for us to focus on the outcomes of LIM as well as the processes. I am sure that ALIC has a very important role to play in encouraging a national focus on outcomes. To quote from the February, 1991 newsletter of ALIC:

> *"ALIC has moved up to another level of activity . . . ."*
> *(ALICNEWS Feb., 1991)*

REFERENCES

Annual Report of the Australian Land Information Council 1989-1990.
Report of the Second National Workshop on Natural Resources Data Management, Adelaide, 31 Jan. - 1 Feb., 1990.
ALICNEWS, Newsletter of the Australian Land Information Council, Vol.3 No.1, February, 1991.

APPENDIX A *

The workshop produced the following list of eleven recommendations for ALIC:

Recommendation 1:

ALIC recognise that there exist three fundamental data sets to support information systems dealing with natural resources data:

- Framework for Geographical Registration (essential)
  - Named roads and streams (including coastlines)
  - Relief
  - Generalised Cadastre (e.g. public land)
  - Gazetteer of Sites
  - Geographical and Australian Map Grid co-ordinates
- Backdrop Data to the Framework
  - Land Cover
  - Administrative Boundaries
  - Restrictive Sites
- Jurisdiction-wide Natural Resource Data Sets
  - Water Resources
  - Soils
  - Geology
  - Natural Vegetation
  - Climate
  - Basic Land Use

Recommendation 2:

ALIC resolve the issue of Commercialisation (including copyright and other restrictions) versus Public Benefit to maximise the use of these fundamental data sets.

Recommendation 3:

ALIC recognise the need for the Framework and Backdrop data across Australia to be available in two years. This data is needed to support:

- National Forest Inventory
- Decade of National Land Care
- National Land Capability Survey
- National Land Degradation Survey
- Protection of natural data capture investments
- Minimising further data capture duplication
- Optimising the operation of existing systems.

Recommendation 4:

ALIC pursue with tertiary education bodies the need for appropriate education and qualifications in land information management.

Recommendation 5:

ALIC members advise appropriate ministers on national and other co-ordination councils of ALIC activities in the natural resources data domain including revision of the National Strategy.

Recommendation 6:

ALIC alert appropriate national and other co-ordination councils to the needs identified in this workshop and work with these Councils to satisfy these needs, particularly in the development of standards.

Recommendation 7:

ALIC advise the Forestry Council of the results of this workshop as the first in a series of opportunities to interact with discipline based workshops in the natural resources area; this to be done with the aim of obtaining reciprocation on the results of this and successive workshops.

Recommendation 8:

ALIC endeavour to ensure that appropriate national standards are developed and implemented in agencies processing land related data.

Recommendation 9:

ALIC recognise that availability of the fundamental data sets in digital form is essential for effective natural resources management in Australia.

Recommendation 10:

ALIC identify and publicise points of access for data indexes and directories.

Recommendation 11:

ALIC identify mechanisms for achieving the above recommendations.

The workshop agreed that these recommendations be passed through AACLI to ALIC.

It was agreed that a report of the workshop be prepared and that this would be distributed to all workshop participants and also widely throughout the land information community.

The workshop concluded with general recognition of ALIC being the peak council for land information management and as such, the appropriate body to implement national co-ordination of natural resources data management.

Although the need to convene a further workshop was not formally recommended, there was expectation from many of the participants that one would be convened within twelve months.

* Extract from Report of the Second National Workshop on Natural Resources Data Management.

MANAGEMENT OF CADASTRAL DATA IN A LAND INFORMATION SYSTEM

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ABSTRACT

This paper looks at methods of capturing, storing and managing cadastral data for a Land Information System. It explores the use of the record systems, and the data manipulation techniques which are used by surveyors to process cadastral data, and the feasibility of working directly from source data rather than simply digitise cadastral maps.

INTRODUCTION

The cadastral network is a key element in any land information system. It is continuously changing as parcels are aggregated and subdivided, roads and other service corridors are added, widened, and re-routed, and as titles change hands. New South Wales has a numerical cadastral system based on individual survey plans with the accuracy of the data being dependent on the date of survey. At present, there is little geodetic control, but each survey is connected to the adjacent surveys. Most systems analysis and management experts regard the current process as a complex unmanageable morass, yet the day-to-day operation of defining boundaries and subdivision proceeds without a great deal of difficulty as is evident by the low level of litigation in this area.

The essential problem is therefore how to efficiently make use of this data to build and manage the cadastral network.

Early surveys for alienation of land from the Crown were performed by government surveyors, but after about 1850, most subdivisions, and many Crown surveys have been carried out by private survey firms.

To-day, most of the source data, and most of the knowledge about the cadastre is held by private survey firms who also carry out and manage most of the changes to the system.

Surveying practices have extensive record systems which have copies of survey plans for a large proportion of their operational area, and original field notes and work sheets going back for many years. These records contain much unique data. It should be noted that less than a third of all cadastral surveys result in a plan being lodged in the Land Titles Office (LTO). When a plan is lodged, it does not show all of the current survey information, and even though computers are used to generate the data for most survey plans, the LTO does not make use of any of this machine readable data.

DATA CAPTURE BY DIGITISING

Co-ordinates for the NSW Land Information System are currently being derived by digitising cadastral maps. The technique uses data of variable quality, requires a high initial cost system for data input, and is not structured to be easily updated from new subdivisions.

The current cadastral overlay for the 1:25000 and 1:4000 series of maps was drawn by the "let in" process in the 1970's. The boundaries were traced from enlarged copies of Parish Maps, Valuer General index sheets and other source documents with control being provided from fence lines plotted by photogrammetry. Most of the source documents were administrative maps where scale and correct geometry is often distorted in order to display certain administrative detail. No attempt was made to check whether the fence lines used as control were anywhere near the actual boundaries. Complicated detail was omitted to reduce clutter with the topographical features, and the resultant maps incorporate most of the mistakes and gross errors which would have existed in the original administrative maps.

It is totally incorrect to assume that the cadastral overlay on these maps is anywhere near to the accuracy of their topographical features, and the poor accuracy and lack of detail precludes its use except for broad scale scanning processes. Digitised values from these maps have no use in the production of a positionally accurate digital cadastre since the effort needed to clean up the data sets is greater than the effort needed to build the system directly from source documents.

New South Wales is currently making moves towards introducing a survey accurate co-ordinated cadastre which is envisaged to alternately replace the map data.

DIGITAL DATA FROM SOURCE DOCUMENTS

A co-ordinate is no more than an estimate as to the current geographic location of a point. It is a type of dimension, and must be subject to revision from time to time as better positional information becomes available. It is a mistake to think of a co-ordinate as a fixed entity, any more than one can say that a boundary is a certain length exactly, or a certain bearing exactly.

Within ten years the Global Positioning System (GPS) will become common place as a measuring system in most sectors of the community. Cost will rapidly decrease along with great improvements in portability, speed and accuracy.

Its use will not be limited to the surveying profession, for it will become a precise positioning system used by the whole community.

It is essential that co-ordinates provided in cadastral record systems are of an accuracy so that they can be used to find their relationship with other data sets such as those provided by service authorities such as, for example Gas and Water. The problem is to derive co-ordinates for the **legal position** of cadastral boundaries, and as survey data is evidence as to their most likely position, it is logical to use this data to determine the corner co-ordinates.

Any system which can co-ordinate the cadastre from source documents can also be used to help resolve conflicts in problem areas and to update the system as the day to day process of subdivision and re-subdivision proceeds.

Many schemes have been proposed, and some pilot projects have been run to generate a "co-ordinated cadastre" from survey plan data. These efforts have in general been instigated by the government, and consequentially they have approached the problem from a view of the data as seen by that sector. Because of this approach, the operators have had access to less than half the available data, no easy way of evaluating its quality, and little use could be made of the connectivity between parcels, and the structure of the parcel network itself. Essentially such schemes work on the system from the outside rather than sympathetically from within using software not designed to be efficient in cadastral management. This approach is very costly, difficult to organise in a systematic way and requires staff with a high degree of survey knowledge at every level in the operation.

The inevitable result has been that it is now the "accepted truth" that it is too difficult and too costly to try and make use of this source data.

A recent study by Elfick and Fryer (1) has used a completely different approach. They used interactive computer techniques with specially tailored software to assemble the cadastral framework and apply control to adjust and check the data. The software used was compatible with the systems used by surveyors in boundary definition and subdivision work. It provided a complete data management system and allowed people with little surveying knowledge to perform the routine data entry work and maximised the performance of skilled staff. Use was also made of data from the record systems of the private sector, and some of the techniques in common use to resolve boundary problems.

Unit costs for the initial data entry from source documents were $1.87 per parcel and 19.8 cents per line. With better search and more experienced operators, they estimate that the cost of data entry could fall to $1.50 per parcel. The cost of model joining, and the initial adjustment was approximately $2.00 per parcel, and the total cost per parcel including the cost of obtaining all source documents was under $6.50 per parcel and there is considerable scope to reduce these figures in a production system.

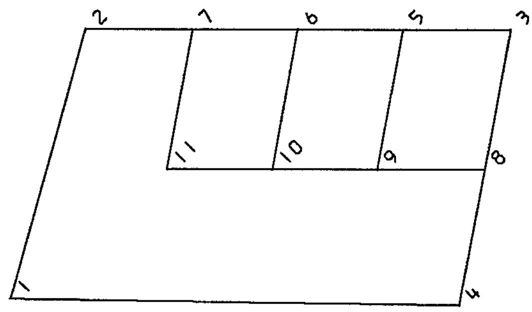
The project has demonstrated that if the appropriate techniques are used, then the cost and speed of data capture from surveying documents can approach the cost and speed of digitising from cadastral maps, but there is a quantum difference in the quality, accuracy, and completeness of the data.

CADASTRAL DATA STRUCTURES

Before designing any data system it is essential to look closely at the data itself and its structure. Nearly all current Land Information Management Systems treat cadastral data in map form since most of these systems have grown out of graphics packages, and sellers of computer hardware and software are skilled at marketing this type of product. Just because such systems have been able to be used in other countries with other types of cadastral data does not mean that they are at all applicable to the best solution of our problems.

The cadastral framework in NSW is essentially built from two types of data. The first is vector information where points are linked by bearing and distance to adjacent points. Original Crown surveys, older subdivisions, and the surrounds of modern subdivisions are of this data type.

The second type is where the framework is defined by its structure, consider the following:



If this plan is a subdivision of portion 46, then the surround is of the first type and can be described as follows:

FROM	BEARING	DISTANCE	TO
1	15 00 00	200.00	2
2	90 00 00	300.00	3
3	190 00 00	200.00	4
4	270 40 00	317.00	1

The subdivision itself can be defined as a structure, with the surround as a constraint. There are many ways that this can be done, but here we will use the syntax of the Association of Consulting Surveyors Geometry Package (2) as follows:

FROS	5	3	75.0	B 3	2				7
STAN	8	3	P-100.0	B 3	2	3	B3	4	
FROS	9	8	75.0	B 3	2				11

The first line uses the Front Straight routine (FROS) to fix point 5 75.0 metres from point 3 on a bearing the same as the bearing of the line from point 3 to point 2, and then continue with this sequence up to point 7.

The second line uses the STAN routine. From point number 3, looking towards point 2, Point 8 is established at the intersection of a line which is parallel to, and 100 metres to the left of the line 3-2 , and on a line from 3 on the bearing from 3 to 4.
The third line uses the Front Straight routine to fix point 9 75.0 metres from point 8 on a bearing the same as the bearing of the line from point 3 to point 2, and then continue this sequence up to point 11.

This method of describing a geometric structure is like a fourth generation language and can be used to concisely define any geometric framework.

Software such as the ACS Geometry package have been in use for over 25 years and many survey firms now define subdivisions by means of structures.

Many plans submitted to the Land Titles Office are derived from co-ordinates created from structure data. The surround is closed, and the misclose distributed before the internal dimensions are computed. There are no miscloses on the internal lots, and marking is carried out by fixing points according to their structure co-ordinates.

On the other hand, most rural subdivisions are fixed by running the actual boundaries, as are urban subdivisions where boundaries pass along existing physical features such as walls. The dimensions on these survey plans reflect the actual measurements taken in the field. With older subdivisions it was also the practise to distribute the surround misclose through the lots, so both forms of source data (vector and structure) will continue to exist for a long period of time.

Where a subdivision has been defined by structure, parcels can be described by reference to the point numbers of the corners. The parcels for the above subdivision would be defined as follows:

LOT 1	2	7	11	8	4	1
LOT 2	7	6	10	11		
LOT 3	6	5	9	10		
LOT 4	5	3	8	9		

A cadastral management system must recognise the actual nature of the data and incorporate source files of both vector data, and structures.

Co-ordinates are only temporary derived quantities which change as more information becomes available. They are simply another form of dimension, and as such are subject to revision as further measurements are taken, or when an adjustment of the data provides a more likely estimate of the positions of points. By describing Parcels in terms of the point numbers of their corners, then the linkages between parcels is uniquely defined, and the actual exact position of each point can change as needed.

RESOURCES IN THE SURVEYING PROFESSION IN NSW.

The Cost benefit study (1) looked at the resources within the surveying profession in NSW. They found that 89% of firms operate computer systems, and 99% of those firms with computers were using IBM-PC (or compatible) systems. Various computer peripherals were in use, with 27% using an X-Y digitiser and 91% using an X-Y plotter.

Of the users of the IBM-PCs all used MS-DOS as their basic operating system with only one firm using OS-2. Less than 3% of firms used UNIX systems.

The distribution of the software types was as follows: CIVILCAD: 100, GEOCOMP: 20, ACS-GEOM: 25, WESCOM: 10, FORESIGHT: 19, LANDMARK: 37. There were about 45 firms which used other types of software such as AUTOCAD, which were used as well as one of the other proprietary brands.

Of the software systems CIVILCAD is the leading supplier, and one of the reasons that this software system is so popular is that it has become firmly entrenched in local government Councils throughout NSW with approximately 100 installations.It has also almost 100 installations in Civil Engineering firms.

In Summary:

160 survey firms in NSW operate computer systems
200,000 parcels of land are held in their computers
90% of this could be supplied to the Land Information Centre

DISCUSSION

The cadastral record system has been managed for the last 150 years by a system which uses the skills and knowledge of the private surveying sector. The Lands Department and Land Titles Office has provided quality control, storage systems for plan and title documents, and facilities for the public to have access to these documents.

Over this time an effective working system which combines the strengths of both sectors has been established with active committees to provide the machinery for adapting to change as the need arises. The way that the Land Titles Office and the surveying profession has coped with substantial changes in work flows and adopted appropriate new technology in recent times is one of the success stories which is seldom publicised. Yet in setting up the Land Information System, none of the skills, and little of the data and the capacity of the private surveying sector has been utilised. We seem to have deliberately ignored the current effective operating model simply because it was not obvious how to work with this system.

In the past no real attempt has been made to take in new data in machine readable form, nor has there been much effort put into devising procedures for capture of digital data directly from the current records. Instead we have simply adopted systems from other countries regardless as to whether they are really appropriate for our type of cadastral system. If you consider the cost to date, the resources so far allocated, and the progress achieved, then it is clear that it is time to have a detailed look at alternative ways of managing the cadastre.

Recently The State Land Information Centre has started funding projects involving the private sector and local government in introducing co-ordinated cadastres in various parts of NSW. The projects are predicated on obtaining the local knowledge and cadastral information held by surveying practicioners. At present, the methodology used involves connection of cadastral corners to the State Survey Control. Part of the program is the development of a Survey Database to hold bearing, distance and co-ordinate data and accept these data directly from practicioners in digital form.

The study by Elfick and Fryer has shown that, with limited use of control points, the existing cadastral data can be directly used to form a co-ordinated cadastre, and has provided an estimate of the unit cost of the technique used. A skilled work force, and the machinery for managing and assuring quality control has existed for a long time.

The potential benefits extend beyond the initial data base creation task, for the system can provide a method for checking new plans and updating the co-ordinated cadastre as part of this checking process. It can also be used to isolate and correct errors in the current data as well as other more routine tasks such as producing computer drawn plans from boundary descriptions. It provides a means of generating and maintaining a "complete cadastre" which will automatically improve in quality as extra data is added, for the addition of extra data provides a means of checking and increasing the accuracy of old records.

Digitising from cadastral maps is a dead end process, and the data which can be extracted from the NSW cadastral maps is of very low quality both in accuracy and in detail. The major reason for its use is that it can be used to generate a full state coverage in a short time period and at a relatively low cost. It is probably far worse than was previously assumed because of the history of the source documents. Such data cannot be easily revised or upgraded. It is easy to simplify and generalise data,
but very difficult if not impossible to perform the reverse process.

On the other hand, the digital technique is a continuous process which progressively improves the quality of the data set as information is added.

Digital extraction from source data can be organised in a completely decentralised fashion with each Land Board District responsible for data capture and supervision of contracts in its area. The Land Information Centre would then utilise both the data and the expertise of the private sector.

The Land Information Centre could provide overall control of such a scheme, but would not need to prepare the type of contract documents and base maps as is necessary with the map digitisation process for contracts could simply be let on a parish by parish basis with the contractor being responsible for the assembly of a complete data set. Suitable firms would already have most of the data for their area, and would only need to order a limited number of plans to complete the local data set. The adjustment process provides a detailed numerical quality assurance of the data sets, and will greatly simplify the post processing needed to incorporate the data to a land information system.

By utilising the existing resources in the surveying profession, and the type of quality control management systems which already exist there is no reason why cadastral co-ordination from source documents could not be carried out as quickly as map digitisation.

If we take into consideration the full cost of cleaning up digitised data and establishing a system which is automatically kept up to date, then the map digitising may also prove to be more expensive in the long term.

REFERENCES

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LAND INFORMATION MANAGEMENT; THE INSTITUTIONAL ISSUES

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ABSTRACT

The introduction of Spatial Information Systems' technology has serious implications for the way in which we manage data as well as the manner in which organisations and institutions will need to operate in the future if we are not to waste our investment in these new systems. To date, most of the emphasis of this new technology has been directed at its flashier aspects - the outputs and applications. Very little attention has been given to the data, institutional and people management issues that are rapidly emerging as this technology is more widely adopted. Even less attention has been given to how best to implement these systems that can have such significant implications for the way in which organisation will operate in the future.

This paper describes the traditional institutional environment of land-related data, identifies some of the barriers of this environment to the introduction of land information management procedures adequate for the new technology and emerging needs, and sumarises some of the solutions adopted in various jurisdictions to overcome the hurdles and institutional barriers.

THE INSTITUTIONAL ENVIRONMENT OF LAND INFORMATION

> 'By its very nature, GIS implementation is a technically mundane, long-term process which may explain why executive management does not become intimately involved beyond funding the project' (Van Denover, 1991)

In Australia, because of its Federal nature and the rights (or lack thereof) of the various members of the Federation with respect to income, a major focus of jurisdictional revenue raising has been land. Examples of revenues appropriated from land are land tax, stamp duties on conveyancing and rates.

States and territories therefore have a particular interest in, and historically are especially responsible for land administration stemming largely from the history of the various colonies established in Terra Australis after 1788, whereby all land was vested in the Crown and the administrators of each colony progressively made it available on a freehold basis to settlers.

The legal basis of freehold land registration is the Torrens Title used universally by all jurisdictions. Land still vested in the Crown which in New South Wales is more than 40% of the land area, is administered and managed by what are by Australian standards at least, historic government departments. In some States Crown Land, whether leased or used for special purposes such as reserves or national parks, is registered in the Torrens System, but in New South Wales there remain large tracts of Crown Land recorded only on maps and not yet formally registered and certainly not computerised.

Over the years each jurisdiction has also developed separate agencies for aspects of land administration other than Torrens Title administration. Valuer General's Departments exist in most States to provide central management of land valuation upon which local government rates, utility service rates and land taxes are based. In the larger cities such as Sydney, large utilities were established, such as the Sydney Water Board which supplies water and provides sewerage services to 1.5 million properties - over 60% of the properties in the State.

As if two tiers of Government is not enough, the well developed network of local councils with populations ranging from over 200,000 to less than 1,000, (apart from Brisbane City Council of over 1 million) relies heavily on revenues largely dependent upon land value-based rates to supply local services such as kerbing and guttering, garbage pick-up services, libraries, etc.

This myriad of agencies involved in using land for revenue raising or in providing services based on land has led to a proliferation of land administration systems in each jurisdiction that are not compatible and duplicate land data collection and maintenance. Across Australia, different jurisdictions with similar functions have non-compatible land management processes leading to a situation where land data is not easily available nationally because of the jurisdictional and organisational differences. In the mid-1980's Australia's land administrators were cautioned by a senior member of the judiciary that they were leading the country into a new "Tower of Babel"; pity the real estate agents and solicitors operating along State borders.

NATIONAL COORDINATION OF DATA MANAGEMENT

The Australian Land Information Council

The Australian Land Information Council (ALIC) is responsible for national coordination of land information. Its role is to

- encourage cost efficient access to land information throughout the nation in order to provide a sound base for effective decision-making on the social and economic management of land at all levels of government and the private sector, and
- provide mechanisms for efficient data transfer from source to users.

The main vehicle by which ALIC is achieving these objectives is the National Strategy on Land Information Management. Note the use of the term land information management rather than information "system". This reflects increasing recognition that the data is the issue not the technology.

Ten key land information management issues have been identified in the Strategy, for each of which is established a series of principles for land information management.

The first edition of the Strategy was supported by an action plan designed to address objectives which were identified as areas needing resolution under each key issue. The immaturity of ALIC was such that the Action

Plan concentrated on process rather the "action' and the main outputs were somewhat ineffective discussion papers.

A significant change in the last year has seen the production of a series of papers - called Issues in Land Information Management - designed to provide useful guidance to land information managers within and outside government. Issues covered to date include key issues such as data trusteeship, charging for land information and copyright, royalty and data use agreements. In response to the increasing call by governments for their agencies to take a more commercial stance, ALIC will shortly issue a paper which considers the land information management conflicts and contradictions that can arise when trying to balance public good and commercial objectives especially in establishing corporate land information systems.

ALIC has also begun to take positive action to identify issues and encourage coordination in areas such as natural resource data management. It also has developed a close relationship with Standards Australia so that land information management standards developed in the various jurisdictions and nationally acceptable can be placed into the public domain and ratified as national standards with government and private sector backing.

ALIC's new action plan

An important change occurred in late 1990. ALIC agreed to take a more positive approach. It recognised that despite its work to date it was not without criticism from among those it was trying to assist. It decided that a more definitive mission statement was desirable and warranted and in September 1990 eschewed the standard bureaucratic do little fallbacks of 'to encourage', 'to facilitate', 'to co-ordinate', 'to provide a forum for...'. Instead it adopted a new role:-

> to provide <u>leadership</u> for effective management and use of land information in the interests of the nation.

Associated with the new mission is a more active action plan which contains a number of specific actions that will be undertaken budgets permitting. Examples of commitments already made are to sponsor a support group for the proposed Spatial Data Transfer Standard, to publish a glossary of terms and to publish a guide on how to access land information throughout Australia. AACLI made a number of other recommendations but jurisdictional budgets precluded actions such as an assessment of the needs for land information management skills being included in this year's programme. While this is unfortunate we should not be too downhearted. The major mechanism by which national coordination and transfer of land related data will occur is via standard setting and the commitment to the support group is perhaps the most significant action ALIC has yet taken in its short history.

LAND INFORMATION MANAGEMENT IN THE JURISDICTIONS

Each jurisdiction is at a different stage in the establishment of land information management systems. The environment ranges from the approaches of States such as South Australia and New South Wales where the land information of a number of agencies is being integrated, to other States where computerisation of basic records such as land titles is only just being planned. In the latter however, are some fairly advanced examples of natural resource management systems such as in Tasmania where forest management has had a high priority.

It is fair to say that much of the thrust throughout Australia towards land information management integration has concentrated on cadastral parcel-based data although design of such systems has incorporated an ability to embrace natural resource data at a later stage. However, some urgent impetus in natural resource systems is now taking place as a response to greater environmental responsibility and concern; environmental matters do not recognise State boundaries and inter-jurisdictional agencies are at the forefront of integrated systems. Interestingly, the issues now arising in respect of natural resource data management are the same as those already identified in the systems that had cadastral data as a priority - lack of data consistency, poor integrity, lack of standards, etc.

Every two years the Australian Land Information Council publishes a Status Report of the work underway in each jurisdiction in Australia and New Zealand. The most recent version was published in November 1990 and readers are referred to this Report (ALIC, 1990).

THE INSTITUTIONAL ISSUES

Responsibility for integrated land information management

The issues that involve land are many and varied. As a result, it is unlikely that any single government agency could be the repository of all information about land. Effective land information management is therefore about co-ordination. However, modern management processes generally being introduced by governments require that responsibility for land information management be allocated to someone or to some specific agency. Certainly, experience is that mere co-ordination based on concensus will not result in effective land information management because of the competing priorities and needs of the individual agencies concerned.

Therefore, responsibility for overall land information management needs to be identified and allocated. Where such responsibility should be located within a bureaucracy has been discussed elsewhere (Hart 1985). Suffice to observe that different jurisdictions will have different views on where it is appropriately located. Indeed, such views will change from time to time, and it is not an uncommon experience for the responsibility to migrate from agency to agency and from portfolio to portfolio. In New South Wales, the land information management integrating body (SLIC Directorate) since it became operational in 1985, has had six different Ministers, been in four differently constituted portfolios and had its parent agency's composition significantly changed twice. At one time during the period, it was due to change portfolios. Other jurisdictions can recount similar experiences.

The status of the integrating agency is also a matter of concern. Generally, Australian custom has been to place the actual responsibility with a committee (of varying stature) but to locate the operational aspects within an existing department. The function is therefore in danger of being subservient not only within the agency within which it is located but also in relation to the other land information agencies many of which are likely to be departments in their own right.

New South Wales has obtained approval in principal to upgrade the agency responsible for the land information integration function, but this has yet to be put into operation. Other States, notably Western Australia, have given close consideration to this option, but to date have chosen to retain the function within an existing organisation.

Data Trusteeship

Allocation of integrated land information management to any one agency does not however, absolve others with a land information management role from responsibility. The approach normally adopted is akin to data processing data management procedures. Individual agencies are nominated as 'trustees' or 'custodians' of particular individual data items (ALIC 1990). It is the responsibility of trustees to keep the data item up-to-date, and to establish in conjunction with all users appropriate standards for its storage, classification and maintenance. No other agency is officially allowed to amend the data item for which another agency is trustee. If this occurs, immediate lack of integrity in land information management results.

While the principles of data trusteeship are well documented, they are not always easy to implement. Difficulties that may emerge include:

- data management priorities of trustees might differ from priorities of the LIS integrator

- data quality needs of trustees differ from those of an integrated system

- trustees are not always keen (because of tradition or lack of funding) or able (because of lack of necessary skills) to change long-standing data (mis)management procedures

- agencies, through being trustees, assume greater than warranted management control over the integrated LIM function

- agencies will protect their own interests and business objectives from what they might consider undue intrusion or competition.

Professional commitment

Because land information involves many agencies and has historically been in the hands of certain professions (e.g. surveyors, lawyers, valuers, cartographers), there has often been what might be termed a jockeying for key roles in the land information system bureaucracy. Before the field developed a degree of maturity there is considerable evidence that certain professional groups considered themselves best skilled and placed to provide the integrated management necessary to implement appropriately modern land information management procedures.

To a great extent, such professional competition seems now to be at a low ebb. Is this because of a recognition that the GIS/LIS/LIM arena is large enough to accommodate everyone? Or is it an acknowledgement that land information management embraces not one but a range of skills, some old and some new? It is not now uncommon for many professional bodies to include sessions on GIS/LIS in their annual conferences and seminars

It is now clear that appropriate land information management does involve many skills. The critical component of successful land information management is therefore ensuring the harnessing of the different skills and enabling them to work together and in concert.

Users and producers

Those with an interest in land information can be simply categorised into producers and users. Traditionally, the producers of land information have determined the information management procedures, set data standards and decided what data should be collected and where. Some producers are also users of the data they produce but many of the producers should in fact, more logically be considered 'users'. Some current producers are really users that had to become producers because the traditional producer has been unable to meet certain user needs, e.g. the extensive base map digitising by some of the larger public utilities.

The outcome has been that users of land information have often been neglected in the push towards better land information management. The emphasis has tended to be upon the needs of the producers for better practices rather than upon the needs of potential users. In other words:-

> 'land information systems have tended to be based upon offering better management processes for existing data systems. Very few, if any, indicate how the better coordination of existing data will provide new information to improve, facilitate or accelerate the decision-making process' (Hart 1985)

Skills and staffing

A corrolory of the inter-professional imperitive of integrated land information management is that new skills need to brought to bear to land information. Therefore teaching of the skills relating to computer science, planning, geography and the like need to change to embrace the special needs of land information management. Similarly, the traditional land information management professions are acquiring additional skills that will equip them to handle the new approaches to land information.

The response of educational institutions has in some instances mirrored that of bureaucratic institutions. Some tertiary departments, schools and faculties have even amended their names in an attempt to claim the 'new frontier' for their traditional clients. There is a danger that tertiary learning is not responding adequately to the inter-disclipinary nature of land information management (AURISA, 1985).

Similarly, until very recently, there has been a lack of LIS/GIS skills within the private contracting and consultancy market-place, where so many government agencies look to overcome skill shortages of their own. Indeed, the first major consultancy employed by the NSW State Land Information Council (1986-88) was one of the first in the State and it certainly provided a fertile environment for a number of consultants to get initial and basic experience in the LIS field, within which they have become LIS/GIS/LIM experts. The tendency for traditional consultancy firms to approach GIS/LIS projects in a manner similar to any information technology project is slowly changing as some of them set up specialist GIS units and other specialist consultancies become established in competition.

ADDRESSING THE INSTITUTIONAL ISSUES

All jurisdictions have had to cope with various institutional issues as they have moved towards improved and integrated land information management. There are a number of well-documented common themes and approaches which included:

- inter-agency co-ordination and policy committees
- special purpose committees addressing common themes e.g the SLIC Natural Resources Data Sub-committee
- formalised project management (e.g. Spectrum) involving (and committing) affected agencies)
- user consultation and information e.g via Newletters, direct contact, etc.
- some centrally allocated funding to influence priorities

However, no amount of sophisticated consultation and image building will lead to successful land information management if the basic concepts and structures are not right. Bullock (AURISA, 1989) citing others (DUNPHY and DICK, 1982) has documented the critical issues as:-

- clear objectives
- realistic and limited scope
- informed awareness
- good timing
- participation
- support from key power groups
- open and continuing assessment
- competent multi-skilled staffing support.

Different approaches are appropriate at different stages in land information management development. For example, cooperation is an essential ingredient, but alone it is likely to prove inadequate sustenance. Ultimately, the case for a separate dedicated agency seems irrefutable, to the initiated at least. However, how the power-brokers can be convinced that such an agency should be established and on what basis, remains a further institutional hurdle of significant proportions yet to be negotiated in any jurisdication in Australia.

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DETERMINING THE WILLINGNESS-TO-PAY (VALUE) FOR LAND INFORMATION: CONCEPTS, CONFLICTS, SUPPOSITIONS AND STRATEGIES.

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ABSTRACT

In a number of countries, land information in various forms is still supplied as a public (social) good at relatively low prices and funded mainly from taxation. Elsewhere, the imposition of user-pays charges has led to substantial increases in the prices which consumers must now pay. The advent of sophisticated Land and Geographic Information Systems, relying on digital topographic and other data as basic inputs, adds to the debate on such economic issues.

Yet, the charging schedules for land information, of whatever economic hue or political flavour, often bear little relationship to the actual value ascribed by consumers. This paper reviews the willingness-to-pay (demand-revealing) process applying it to information and land information in general terms and drawing on techniques developed during two studies into topographic mapping provision in New Zealand and Australia respectively.

INTRODUCTION

For a considerable time, governments worldwide committed themselves to the provision, and usually the production, of land information in the form of national mapping and surveys mainly because they considered it to be in the national interest. Given finite public resources and restless taxpayers, not to mention politicians hell-bent on reducing internal deficits, the situation is less clearcut for modern land information programmes and difficult policy questions arise in this area. What land information coverage do we really need? How detailed and accurate does it have to be? Should we revise existing topographic mapping and how? What price should users be charged for access to land information? Who owns it and maintains it? And so on.

Many economists and politicians alike believe that such questions can be addressed only with the benefit of applied empirical studies aimed at teasing out the costs of such programmes and balancing them against the benefits well before embarking on commitments to fund them. Those entrusted with the task of obtaining a monetary value for the benefits of land information programmes, projects and products have seldom found it a simple endeavour - markets do not exist and charges are non-existent or determined arbitrarily. Moreover, what exactly are they trying to value and from where or whom can a measure of value be obtained? Some interesting cost-benefit analysis, and mutants thereof, have resulted. And, when information about preferences, and the monetary measure of those preferences is not readily available in marketplace prices, then asking people what they are willing to pay directly, indirectly, deliberately and even deviously, can help.

This paper is divided into two parts. The first part sets the scene, especially for non-economists, by reviewing necessary concepts. Part Two brings these concepts to bear on land information in a general sense, using examples from two studies into topographic mapping provision to illustrate particular points.

PART ONE - VALUE AND WILLINGNESS TO PAY

1.1 Alternative concepts of value

Questions such as *How much is this land information worth to you?* or *What value would you place on a cadastral map?* actually serve to introduce a veritable minefield of semantic implications, especially in economic terms:

> "*Four notions are commonly confused when people speak of worth: merit, as intrinsic value; usefulness as value-in-use, or utility; exchange value, as price or value-in-exchange; and best alternative, as opportunity cost. Any of these four may be reflected in an answer to the question "What's that worth?"*." (Wildavsky, 1979)

Essentially, *merit* value is bound up with subjective valuations of goods (or services) although it is often eschewed by economists for that very reason. For example, a battered childhood toy can hold great worth for that same person in later life. *Utility* value holds more sway in economics; consumers are assumed to make rational choices between available goods and services according to an axiom of *utility maximisation*. That is, they plan spending to attain the highest possible satisfaction or utility. (Koutsoyiannis, 1979) Yet, difficulties emerge with actually measuring utility and in its pure form it remains a subjective notion of value. In practice, however, it is useful in explaining the demand side of market theory and, moreover, acted to underpin the development of a value-added approach to evaluating information services. (Strassman, 1985)

The terms *price* and *exchange-value* involve the marketplace directly with price reflecting a convenient, collective meeting point for buyers and sellers. Economic factors such as *marginal utility* and *scarcity* are important here, and early economists noted a necessary distinction between *exchange-value* and *use-value* as the *paradox of value* where:

> "... *the most useful things, such as air and water, commanded a low or zero price, whereas rather useless things, such as precious stones or pearls, fetched highest prices. The solution to the paradox lay in consideration of the relative quantities in which the various goods or services are available*" (Machlup, 1980)

In the absence of barter, when a formal transaction takes place the good or service has a monetary exchange-value which includes the exchange price but also the time and effort the purchaser expends to complete the transaction. Price can also indicate marginal utility - the value to the consumer of acquiring an additional unit of the commodity.

The final concept of value involves the *alternative opportunities* which are necessarily forsaken when acting. Here, decision cost is seen essentially as an estimate of the benefits which could have been obtained - the opportunity cost lies with the highest-valued or best alternative. Each of these concepts can play a part in valuing land information.

1.2 Consumer surplus and willingness-to-pay

We can safely assume that people are not normally willing to pay for something they do not want. Whilst the agreed market price is useful, it can undervalue the true worth or benefit to the individual or to society. Introduced into mainstream economic theory by Alfred Marshall, although used by Dupuit earlier, *consumer surplus* denotes the difference between the maximum amount a consumer would be willing to pay for a product or service and the amount she actually pays. (New Palgrave, 1987)

> "*Consumer's surplus should always be added to the market value of goods and services consumed to obtain a proper estimate of total economic benefits.*" (Meister 1985)

Consumer surplus has caveats attached. This is not the place to untangle the Marshallian and Hicksian approaches to calculating consumer surplus (compensating variation, compensating surplus, equivalent variation and equivalent surplus) but some points need exposure. First, there is the use of expressed consumer demand as a direct measure of consumer benefit. If interpreted as the maximum amount the consumer would pay, when non-marginal changes are involved, the marginal utility of income must remain constant. This criterion is met when expenditure is small compared to the consumer's total income. There is also a necessary assumption that the prices of other goods (perhaps substitutes) remain unchanged. Furthermore, aggregating consumer's surplus across a group assumes that their preferences are sufficiently similar. Finally, establishing total value using consumer's surplus, especially if consumers are asked *directly* what they might have been (or are) willing to pay, often concerns economists. They urge caution.

> "... *on the basis of a consumer surplus estimate, the economist is not likely to recommend the introduction of a particular project unless the estimated consumer surplus gain exceeds the estimated loss by a substantial margin.*" (Mishan, 1981)

Not surprisingly, for some goods and services pragmatists may prefer to set value as equal to price or opportunity cost leaving the consumer surplus to fend for itself. But, when the price charged bears scant relationship to either cost or value, e.g. token prices set for equity reasons, or where such distortions have existed for an extended period, even a crude determination of the consumer surplus is useful in determining proper value.

1.3 Benefit assessment of non-market and mixed goods using willingness-to-pay

The value of a pure private good is readily obtained in the marketplace; public goods and mixed goods require different treatment. (Pure public goods display non-rivalness, non-excludability and non-appropriability. Mixed goods are those which yield both private and public characteristics, e.g. national parks or health services. Non-market goods include clean air or a rare species.) Providing or preserving such non-private goods involves benefit (value) assessment mainly because the need for benefits to exceed costs is still a *prima facie* requirement in sound policy formulation and decision-making. Procedures involve identifying and quantifying, in monetary terms wherever possible, the values of such commodities and variants of Cost-Benefit Analysis (CBA); Cost-Effectiveness Analysis (CEA); Environmental Impact Assessment (EIA) and others are employed.

With many mixed, public and non-market goods, two basic approaches to estimating values exist; either indirectly by seeking out surrogate markets or more directly by determining willingness-to-pay through an experimental approach. (A range of methods is discussed in Sinden and Worrall (1979)) Whilst surrogate markets (hedonic pricing) can be useful, the method still requires: a well-behaved market; adequate data about that market; and, considerable statistical skill and effort to distill out the marginal effect on total value of the particular characteristic associated with the commodity being valued.

The experimental market approach is characterised by the *Contingency Valuation Method* (CVM), a particularly popular method of assessing the natural environment, e.g. acid rain effects or natural beauty. (A detailed exposition and critical assessment can be found in Cummings *et al* (1986)). Eliciting willingness-to-pay value is the linchpin of this approach with people being asked directly what they are willing to pay for a benefit or "gain". For example, a simple open-ended question for a mail questionnaire might comprise;

> "*How much are you willing to pay in extra rates to ensure that atmospheric lead levels over Sydney are halved? $......... per year*"

Successful willingness-to-pay applications involve several necessary factors including: the hypothetical market resembles a real market quite closely; a contingent market includes not only the commodity but the institutional context in which it would be provided and financed; and, respondents need familiarity with the commodity as well as the payment mechanism, e.g. a tax or entry charge. (Cummings *et al*, 1986) In practice, personal valuations are sought for increases (decreases) in the quantity of the commodity either through a questionnaire (survey) or using experimental techniques. Thus, willingness-to-pay extracts a value within which a component of consumer surplus is included.

The willingness-to-pay method has its critics. Challenges tend to revolve around various potential biases: hypothetical bias (lack of reality); strategic bias (the free rider problem or fear of having to pay the admitted value); instrument bias (method of payment e.g. unfair taxes); information bias (inability to comprehend the process itself); and, starting-point bias (suggested benefit size begins too high or too low). (Mitchell and Carson, 1986)

> "*The overall conclusion... is that free rider behaviour does exist and is empirically significant. Public good valuation needs to acknowledge the significance of free-rider behaviour and the fact of existence of other biases when eliciting demand estimates for public goods.*" (Throsby & Withers,1986)

The normal problems associated with surveys, e.g. sample size and data analysis (outliers) also come into play. Yet, a substantial empirical literature in a wide variety of fields exists where willingness-to-pay approaches have been used: wilderness protection (Walsh *et al*, 1984); water quality (Smith and Desvousges, 1986); the arts (Throsby, 1984) and education (Gertler and Glewwe, 1990). Whilst the willingness-to-pay method for evaluating demand (and benefits) for public goods, such as environmental quality, has become well-established, the validity of extending the procedure to mixed goods is less clear. Throsby (1984) argues that for mixed goods, e.g. museums, which yield both private and public benefits, it may be necessary to separate out these value components. Moreover, he suggests that in certain circumstances overvaluation of the benefit occurs.

Finally, there is the matter of the vehicle to determine willingness-to-pay values, the basic choice being in-person, mail and telephone surveys where cost, question complexity, response rates, access to respondents, and ease of application all play their respective parts. For willingness-to-pay questions in particular, there is the consideration that;

> "*... questions often involve complex scenarios that require careful explanation and which benefit from close control over the pace and sequence of the interview.*" (Mitchell and Carson 1989)

1.4 Valuing Information

Information is a multi-faceted commodity with a chameleon-like propensity to take on different economic-good characteristics depending on the circumstances and also because:

(1) The product cannot be defined easily as there is no obvious measure of a unit of information beyond the bit which is an inadequate indicator of meaning or value.

(2) Information is neither destroyed in use nor consumed. It is non-depletable in use and mainly non-rival in consumption.

(3) Information may be used and invested simultaneously. This complicates the assumption that price is a full measure of value to the purchaser.

(4) Because of its very nature, *a priori* knowledge of the value of information to the consumer or by the producer is incomplete.

(5) The integrative relationship between information and knowledge makes the information value unique to *that* user for *that* purpose at *that* time. (Utility and value are highly context-dependent.)

(6) Information items may be useless until combined with other items. Also, information is not capable of infinite division.

(7) Information displays various characteristics of public goods and private goods with potential for both positive and negative externalities.

(8) Information producers, e.g. governments, may be large consumers as well as producers. This complicates valuation.

In summary, information and information resources, separately and together, may display economic characteristics of heterogeneity, non-rivalness, non-appropriability, indivisibility in production and non-divisibility in use. The traditional premise that information is a pristine public good has been challenged increasingly. The replacement view sees information as an ordinary commodity with a concomitant presumption that users should be charged for access and for subsequent use. Not surprisingly, similar sentiments are in vogue, and in place, for *land information* products and services. (For a fuller discussion of the public-good/private-good nature of spatial information see Hoogsteden (1989).)

Some observers distinguish between the value of the information *content* (*meaning)* and the value of the information *resources* namely the services or systems which are used to store, manipulate, analyse and deliver the information. (King *et al*, 1981) The value of information (content) relates more closely to use whereas the value of the information product (service) is better quantified in terms of the contribution it makes to the amount of use. Frankly, it is not simple for even knowledgable individuals to separate out these two concepts, quite apart from quantifying their perceptions of the respective values.

> "*Value, the ultimate determinant of information is an elusive concept, probably best understood and measured in terms of specific operational*

criteria or indicators. (Black and Marchand 1982)

If this premise is accepted, then the task of assessing the total value of information is widened substantially as Taylor's (1986) value-added approach illustrates.

1.5 Willingness-to-pay and the value of information goods

Assessments of the value to society of information products using willingness-to-pay techniques are available. For example, an early researcher Berg (1972) used this technique to analyse the value of scientific journals whilst Mason and Sassone (1978) used a similar economic modelling approach to evaluate the costs and benefits of providing information services. Whilst innovative, such uses attracted criticism:

> *"The author [Berg] made assumptions about shapes (linearity) and about parallel and non-parallel shifts of demand curves, which he drew from one axis to the other... He thus hypostatized a teaching device, a heuristic idealized geometric and algebraic model, into an operational set of empirical data, which in fact are unknown and unknowable."* (Machlup, 1980)

In essence, Machlup argued that the price-demand curve can be used to estimate marginal changes in price or quantity but should not be used for determining total values for individuals or society at large. In response, King *et al* (1981) derived the concept of an "effective price" for information which included the price actually charged as well as the price actually "paid" by users in terms of their time and monies expended in acquiring and using the information. (Clearly, this still does not include the consumer surplus.)

PART TWO - WILLINGNESS-TO-PAY AND LAND INFORMATION

2.1 Assessing land information value

Basically, land information benefits comprise user benefits and intrinsic (non-user) benefits. In the main, research efforts tend to concentrate on the former which are often subdivided into tangible and intangible (or less tangible) benefits. Typically, tangible benefits (incremental achievements) are portrayed as quantifiable values, e.g. increased speed of delivery and asset management, with the intangibles being those of accuracy, reliability, currency, integrity and so on. (Many of these so-called intangibles can often be assessed through some form of surrogate measure.)

Extending the work of King *et al* (1981), a general approach to land information values might include:

- An *input benefit* approach (manifest value)
  Benefits determined through indirect willingness-to-pay which adds an

increment to price to reflect the search and transaction costs involved in identifying, locating, ordering, receiving, installing and verifying land information. Alternatively, a survey using a willingness-to-pay based on CVM-style techniques could be used to identify and quantify value (including consumer surplus?). Finally, a third approach might ascertain the cost of obtaining substitutes.

- A *process benefit* approach (consequential value)
  Benefits derived from actual use of the land information, its frequency and degree of use. Using information tracing and impact analysis (value-added) approaches, first-order improvements (including cost-savings and productivity gains) are identified. Typically, quicker policy formulation, increased productivity and better asset management are mentioned.

- An *output benefit* approach (societal value)
  Second-order benefits accruing to society as a whole. Improved knowledge and understanding about spatial relationships, improved national productivity, better use and management of natural resources and enhanced awareness of environmental quality are possible.

- A *risk-avoidance* benefit approach (option value)
  Knowing that the land information asset will be there, if and when the option to use it is exercised, has a value to individuals and organisations. Potential users are willing to pay an amount, perhaps indirectly through taxation, to ensure supply continuation. (National land information coverage is often based on this element due to the need to avoid intolerable delays.)

- An *existence benefit* approach (intrinsic value)
  Intrinsic value as an extension of the option value. An altruistic motive, e.g. ensuring an inter-generational land information archive has asset value. The opportunity to gather certain land information may be time-related and once the opportunity has passed, it is irreversibly lost.

The total value of land information might then be seen as a function (not a summation) of these various contributory benefits.

2.2 Willingness-to-pay and topographic information: trials and tribulations!

A number of interesting economic evaluations and technique appraisals in the wider field of surveying and mapping have been prepared over the years including the Canadian Maritimes LRIS (Larsen, 1971; Ross, 1977), geodetic reference systems (Epstein and Duchesneau, 1984), topographic mapping revision (USGS, 1987:1988), a digital topographic data base (South Australia Department of Lands, 1989), and a cadastral coordinate system for the A.C.T. (Angus-Leppan and Angus-Leppan, 1990). Many such studies, including those concerned with land information, have concentrated on the immediate task in hand, often a cost-benefit style analysis of a proposed programme or project. For sound reasons, emphasis is generally placed on the cost side with the benefits (value) often being dominated by cost savings. The application of willingness-to-pay techniques does not figure frequently. One major reason for this can be seen in an Ordnance Survey (1984) report on user needs for small-scale (topographic) digital map data:

> "*It is difficult to price a hypothetical product for which the level of sales is still unknown... Care is necessary when interpreting the answers to questions about value for money. If a potential customer is asked about prices it is at least possible that his reply will be calculated to protect his own interests. Some respondents may lack the experience to know what the proposed products may be worth to them in increased products or efficiency.*" (Ordnance Survey 1984)

The study goes on to report, somewhat disconsolately, that:

> "*Respondents were asked to say how much they were prepared to pay for each form of data they might be interested in purchasing or leasing. Even this produced very few answers, all for much lower prices than the brochure prices.*" (Ordnance Survey, 1984)

It seems that some of the potential biases noted in Part 1.3 came into play in this instance but the fact that the product is unknown and untried appears to be most influential. The problems of establishing a marketplace for land information are far from over.

Willingness-to-pay approaches have been used in the area of national topographic mapping where the products are, naturally enough, familiar to the sampled users. In a questionnaire survey of over 5,000 users, both economic and general (social) users expressed their willingness-to-pay for alternatives should USGS topographical mapping not be available. (Muller et al, 1968) As a weighted average, economic users were willing to pay $US477 with general users indicating an average of $US5.70. (According to Jennings (1984), the price per sheet was held at $US0.75 until 1976.) By extrapolation, the annual dollar benefits (1969 dollars) were put at $US900,000,000 whereas the total expenditure on the topographic programme since 1896 was $US430,000,000 with the expressed conviction that:

> "*These estimates of benefits are based on user responses and are considered to be conservative. We think that the benefits from map use are considerably larger than most users expressed in terms of willingness to pay or ability to pay.*" (Lyddan, 1971)

There is no comment on the fact that the willingness-to-pay values show a severe skewed distribution and that the weighted average may therefore be suspect. A rather different

USGS attitude towards willingness-to-pay can be found some twenty years later:

> *"The first approach would elicit from the user an estimate of how much the user would be willing to pay for map revision. Although this approach provides an estimate that includes consumer surplus, it was not selected because a value judgement is required on the part of the users of the marginal productivity of map revision within their application. This approach would allow a large margin of error because map users would be required to understand the benefits of their own work and then the component of the benefits that was provided by having current map data."* (USGS, 1988)

This time, the USGS preferred to ask users how much they would spend if current map information were not available which, essentially, is an alternative cost approach.

2.3 A New Zealand Story: Valuing Medium-scale Topographic Mapping

This willingness-to-pay study formed part of a wide-ranging investigation into medium-scale topographic mapping provision and usage in New Zealand. (Hoogsteden, 1989) For financial reasons, a postal questionnaire approach was used with over 2,000 being distributed to selected user groups and also through counter-sales of maps; 800 returns across 230 different variables provided a substantial data-base for analysis.

One key objective involved users' perceptions of the value of the topographic map products. Thus, a crucial element of the study lay with eliciting from users the economic worth of topographic mapping information and mapping products. An early assumption was made that the stated perceptions would be coloured by previous and prevailing prices for such products as well as the various biases discussed earlier. Because such prices had been cheap, below production cost and not linked to inflation, an undervaluation was considered likely. Two strategies were adopted to minimise such effects.

2.3.1. Information versus the map

First, users were asked to indicate the amount which they were prepared to pay for topographic and cadastral map *information* if the standard government-produced products were not available for normal work and/or social (recreational) purposes. Emphasis was placed on the *information* aspect. All respondents received the identical question which was located well before questions concerning the value of standard map products.

2.3.2 The free-rider issue: establishing upper and lower bounds

In an attempt to circumvent some of the willingness-to-pay problems outlined above, especially free-rider undervaluation, two variations (user-pays and nominal) on the question of value were devised as follows:

(a) User-pays version

"It has seriously been suggested that mapping products of Lands and Survey could be placed on a user-pays basis with a rise in map prices a likely consequence. Should this happen, what is the maximum you would be willing to pay, for use in your work, for:

(a)	*a standard topographic map*	*$.........*
(b)	*a standard cadastral map*	*$.........*
(c)	*aerial photograph*	*$........."*

(b) Nominal charge version

"It has seriously been suggested that mapping products of Lands and Survey should be reduced in price, to a minimum handling charge of say $0.30, because they are considered to be of public benefit and should be distributed as widely as possible. If this happens, what savings would this price represent in relation to what you would have been prepared to pay for use in your work for:

(a)	*a standard topographic map*	*$.........*
(b)	*a standard cadastral map*	*$.........*
(c)	*aerial photograph*	*$........."*

Each questionnaire contained only one version and the distribution was random. It was hypothesized that aggregate responses should provide a lower bound and an upper bound on the "true value" which users placed on the various products. In turn, these results could then be compared to the question on the value of map "information" referred to earlier on a group-by-group basis. (As background information, it should be noted that the prevailing price of a topographic map at the time of the survey was $NZ1.50)

Some of the main conclusions from economic users' responses were:

- Responses are highly skewed with outliers in right-hand tails (trimmed means at 1%, 5% and 10% and the median were used to counter this.)

- Topographic information was valued substantially higher than the prevailing map price across all response categories. The mean value was $195.61 with a significant reduction coming with trimmed means of $102.23 (1%), $61.47 (5%) and $36.48 (10%) with the median value of $10.00.

- Mean values ascribed to topographic maps are considerably lower than those for topographic information with a raw mean of $15.57 followed by

$10.19 (1%), $6.06 (5%) and $5.08 (10%) respectively.

- Nominal-group mean responses were noticeably higher than those for the user-pays sample across the board: raw means (nominal = $18.62, user-pays = $13.84), 1% (nominal = $15.25, user-pays = $6.78), 5% (nominal = $9.99, user-pays = $5.68) and 10% (nominal = $5.43, user-pays = $5.11)

- Recreational users also valued topographic maps at substantially more than the then-current selling price of $1.50 with a raw mean of $5.68 and even a 10% trimmed mean provided a value of $3.23, more than twice the price.

From a management point of view, perhaps seeking to justify the programme's worth, such results might be seen as extremely positive. A more appropriate way to obtain a value-for-money relationship was to compare such valuations with the production cost. At that stage, the average long-run programme cost per *distributed map sheet* was calculated at around $4 although not all costs could be included.

2.4 Valuing Medium-scale Topographic Map Revision in Australia

This second example of applying a willingness-to-pay approach is quite different in scale, time and theme to that for New Zealand discussed above. As an integral part of a wider study, it sought to assess the incremental value of topographic information which might result from a revision programme for medium-scale topographic mapping. (Hoogsteden and Williamson, 1990) This report has not yet been released and only an outline of the procedures relevant to a discussion of willingness-to-pay approaches is given here.

It is generally accepted that the utility (value) of topographic information obsolesces with time. However, if topographic maps are stripped down to their basic layers of culture, drainage, relief and vegetation, then the rate of obsolescence will differ between these information layers and a residual value for the composite map will also remain even after a considerable period. Consequently, a primary task could be seen as identifying the decrease in value with time and/or the increase in value with revision.

As with the New Zealand study, the price for medium-scale (1:100,000 & 1:250,000 series) topographic maps in Australia appears to have drifted in relation to production cost and inflation and stood at $A5.50 in 1990. Despite its relatively low price-level vis-a-vis other information goods (services), e.g. digital topographic information, it can still act as an anchor price to determine relative-value changes due to time-obsolescence and revision.

Typical questions which could be used in this case might be (i) a standard question on the *utility* of topographic map information of different ages and (ii) two different versions of questions concerning the worth of topographic maps of different ages in relation to the current price along the lines indicated below. (In each case respondents should be asked to indicate the response for one-year, three-year, five-year, ten-year and twenty-year old maps (or information) respectively.)

(a) Utility question

"Please could you assess the utility (value) in your work, of medium-scale topographic map information of different ages?
(Please use a scale of 1 to 100 where the value of recently-produced and UP-TO-DATE topographic information = 100)"

(b) (i) Value question (premium version)

"It has been suggested that differential prices could be set for topographic information of different origin, accuracy and UPDATEDNESS because of the difference in utility to the user. In Australia, the current price for a STANDARD MEDIUM-SCALE TOPOGRAPHIC MAP is $5.50 regardless of age or obsolescence."

"What premium (additional amount or percentage) would you regard as reasonable for a map whose CONTENT and POSITIONAL ACCURACY was certain to be no more out-of-date than the following time scales indicate?

(b) (ii) Value question (discount version)

"It has been suggested that differential prices could be set for topographic information of different origin, accuracy and UPDATEDNESS because of the difference in utility to the user. In Australia, the current price for a STANDARD MEDIUM-SCALE TOPOGRAPHIC MAP is $5.50 regardless of age or obsolescence."

"What percentage reduction or dollar discount would you regard as reasonable for a map whose CONTENT and POSITIONAL ACCURACY was certain to be no more out-of-date than the following time scales indicate?"

Once again, the purpose in setting the questions is to attempt to reduce the various biases which can occur with this type of valuation task. The task is essentially one of assessing the decline (or improvement) in value without (or with) revision. Whilst the question on utility is relatively straightforward, the intent of the value questions is to instill a greater sense of realism into the situation. Naturally, the responses to these and similar questions on digital topographic information might also be of use to any mapping agency wishing to assess consumer attitudes on pricing and quality. The results should prove fruitful in a number of ways.

CONCLUSIONS

The task of determining the value which users, current and potential, place on land information will seldom be easy. It could be that user-pays and/or cost-recovery directives mean that the task is seen as superfluous anyway and that commercial ends will prevail. Yet, even then, assessment of individuals' willingness to pay certain prices will be of material assistance to those preparing price-schedules for various land information goods and services.

Moreover, if the basis for providing land information also includes some other important objectives - national security, sustainable resource management, environmental protection or similar social goals - then individual and collective preferences and accompanying statements of information benefit (value) become even more important to decision-makers. Then, despite its complexities, the willingness-to-pay approach, or other innovative techniques built upon it, will find a rightful place.

We have not attempted Damascus conversions to willingness-to-pay techniques here and the examples shown are on the straightforward and less-expensive end of such evaluations. But, quite simply, a neat, positive, large benefit-cost ratio will seldom pop out of any assessment without considerable time and effort. Willingness-to-pay is an interesting approach which has not yet been used to full potential in the economic maelstrom which those valuing land information often find themselves swimming rather desperately.

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IMPLEMENTATION ISSUES AND RESULTS IN THE FIRST SIX YEARS OF THE THAILAND LAND TITLING PROJECT

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ABSTRACT

The first phase of the twenty year Land Titling Project began on 1 October 1984 with direct funding by the Royal Thai Government, a World Bank loan and an AIDAB grant for technical assistance. The first phase ended on 30 September 1990 after six years. A four year second phase began immediately with the same sources of funding.

This paper presents a summary of the first phase results focussing on surveying, mapping and titling activities as support to the establishment of an improved land administration system. The results reveal that during phase 1 a very large project was mobilized and quickly put into production. This was achieved by a quite remarkable marshalling of resources; organization, management, training, technology transfer, new equipment, expanded field operations and new land laws and practices. Some of the more important issues that effected project implementation will be highlighted in the paper.

CONTENT

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INTRODUCTION

In 1980 agriculture provided employment for over 70% of Thailand's labour force and contributed 58% of exports. At that time it was concluded that further improvement to incomes could not be easily obtained without degrading the environment unless new policies were initiated; security of tenure and easier access to institutional credit were seen as incentives to more intensive and "smarter" investment by farmers on existing arable lands. The needs in the urban sector and in improved land administration operations were at that time considered secondary.

The Land Titling Project (LTP) is a 20 year project to meet the following goals of the Royal Thai Government (RTG); to issue land title deeds to all land parcels in private lands, to produce one uniform series of cadastral maps in both rural and urban land, to develop a national property valuation system and to improve land administration operations. The LTP implementing agency is the Department of Lands (DOL).

At the commencement of the project, the land tenure status was as shown below (Angus-Leppan et al 1986);

Land Type	No. Parcels ('000)	Area (million rai)
State Land		
Forest	-	162.2
Other	-	40.3
		202.5
Private Land		
Title Deeds (NS4)	4 160	20.8
Certificate of Utilisation (NS3K)	7 400	48.3
Certificate of Utilisation (NS3)	1 000	16.8
Pre-emptive Certificate (NS2)	600	7.9
Undocumented *	4 300	24.4
sub-total	17 460	118.2
TOTAL	17 460	320.7

* estimated by subtraction (note; 1 hectare = 6.25 rai)

Table 1: Land Tenure in Thailand (1985 statistics)

The LTP was created through project identification (1981), preparation (1982/83) and appraisal (1984) steps assisted with loan funding by the International Bank for Reconstruction Development (IBRD, usually referred to as the World Bank) and grant aid from the Australian International Development Assistance Bureau (AIDAB). The first phase ended on 30 September 1990 after six years. The technical assistance input is managed by BHP Engineering in association with Colliers International, Price Waterhouse Urwick, Unisearch Limited and MPW Australia.

The LTP has five major components;

- rural mapping, surveying and titling
- urban mapping
- land administration, including a major building construction activity to allow title deed records to be distributed to district locations.
- valuation, including activities to provide parcel based valuations in Bangkok and block based valuations in the country.
- institutional strengthening, including training and education, organization and management review, and socio-economic impact assessment.

The DOL in 1984 had about 10,000 staff; title deeds were held in each of the 73 Provincial offices; land use rights documents were administered from some 700 District offices. By 1990 the staff had increased to over 12,000 and 51 new branch land offices were operating with decentralized records and 1.6 million new title deeds had been prepared under the project.

The project is managed under the DOL appointed Project Manager supported by a project office with functions of administration, procurement, disbursement, planning, project monitoring, and training co-ordination. The Director-General is Project Director. The project reports to an Executive Committee of RTG agency representatives and is chaired by the Deputy Permanent Secretary of the Ministry of Interior. The technical assistance input is managed by the Australian Team Leader; over 50 advisers have provided assistance during phase 1. The budget for the first phase was US$60 million for operations and an AIDAB grant equivalent to US$9 million.

The approach to project implementation has required a sensitivity to the many environmental factors impinging on and about the goals including, institutional, economic, cultural, human resources, legal framework, geography, infrastructure, security and others. Some key implementation issues will be discussed;

- land management issues,
- project design issues,
- project management and operational issues, and
- sustainability issues

In any long term project the environmental factors above will change. These changes will result in strain being placed on the project, which if it is to be handled successfully will require considerable flexibility in project management. Changes during phase 1 of the LTP will be examined to illustrate the need for in-built flexibility.

It will be seen that a well prepared project design is necessary but not sufficient to sustain a long term land management project.

The results presented in the form of a logical framework diagram (Table 4) illustrates the magnitude of the outputs achieved and their direct relationship to the main goals of the project.

LAND MANAGEMENT ISSUES

Modern Thailand is industrializing rapidly. Government policy this century has been one of progressively providing greater land ownership rights to individuals to support the country's economic development. In earlier times the King granted land cultivation rights to groups of people and individuals who served the King; indeed, the rank of a man was expressed in **rai** which is the Thai unit of land area (6.25 rai = 1 ha). The DOL was established in 1903 and land registration based on the Torrens Title system was introduced by an Australian surveyor Mr. R. W. Giblin whilst acting as the Director, Department of Surveys in the period 1901-1910. However, it was not until 1954 that a Land Code was promulgated and at the start of the project most land tenure was with land use documents, not a full title deed. Whilst, the Thai land administration system has developed to support the economic goals of the country, the social and cultural norms have been an important determinant; for example, land parcel boundaries are always identified by an adjudication process where adjoining land owners come to an agreement (Angus-Leppan et al 1986).

There are a number of broad land management issues impacting on the project.

Forest Encroachment

The Royal Thai Forestry Department (RFD) is responsible for the 50% of the country reserved for forest amounting to 162 million rai (Table 1). Between 1961 and 1985 an estimated 78 million rai of forestland was denuded (Chirapanda, 1986). In recent times forests have been further encroached due to population increase, construction of resorts and recreational areas (to serve the tourism boom and increasingly wealthy urban population), and the planting of fast growing trees, mostly eucalyptus. Major landslips in the South in 1988, led to a formal banning of all logging in the country.

As noted before (Burns et al 1990)," the boundaries of forest reserves in Thailand have always been difficult to relate to other land records" and " often resulted in a corridor where neither agency [DOL nor RFD] was sure of it's responsibilities". Further, the DOL has legitimately issued land documents for parcels within the forest lands. For these two reasons, the project cannot place all legal privately held parcels on the one register and one mapping system. In addition, the RFD issues a usufruct licence (STK certificate) on a 5 years renewable basis to use the land. It is estimated that as much as 30 million rai of forest land is put to agricultural use. Hence, the country has economic activity taking place under two different administrative and legal systems and two sources of land tenure information. The record systems are not compatible.

The above situation is causing operational problems. For the systematic adjudication under the LTP the DOL transfers any forest boundaries shown on 1:50 000 topographic maps (usually drawn freehand with a thick crayon pencil) onto the new 1:4 000 UTM rectified photomap by comparing whatever detail is common. It then proceeds to field adjudicate well inside that approximate boundary to avoid any accusation of issuing illegal documents.

Low Rural Incomes

During the first phase, the LTP operated in 9 provinces in the poorer North and North-East of the country. This has caused some operational problems such as, owners not being present for adjudication because of work commitments in the Bangkok area or overseas, reluctance to pay the fee for the title deed, although it is a nominal fee only, and confusion as to the purpose of the LTP. However, generally the co-operation of the local people has been obtained through the assistance of the village headman.

A more important issue concerns whether or not the well-being of the people has been improved by the provision of title deeds. The LTP socio-economic study is examining this question and a preliminary report indicates increases in farm outputs has followed titling. The study is due to be completed in 1992. An earlier World Bank study in 3 provinces (Feder et al 1988) included Korat and Khon Kaen in the North-East and concluded that the level of output and farm inputs was higher in lands with some form of land tenure documents; output increases were 12% for Korat and 27% for Khon Kaen.

Changes in Social Patterns

In areas throughout the country the influence of the rapidly expanding economy has induced some farmers to sell their family lands for short term gain; in the south and south-east, rice and fruit farms and coconut plantations have been sold and are now fish farms. In the north and north-east, farms are now commercial tree plantations. In the eastern sea-board and surrounding provinces of Bangkok farms have been sold to support industrial expansion and recreation in a pace which is not being matched by the developing infrastructure and which has fueled land speculation: the value of land transacted at DOL has increased from 140 billion baht in 1986 to 540 billion baht in 1989 (US$1 is equivalent to about 26 baht).

The socio-economic study has shown that there is evidence of disputes between family members over formal land ownership which never surfaced in the past because the land was understood to be family land. The study also found evidence of speculation which could lead to landlessness and the subsequent increased migration of rural people to the urban centres or increase in tenant farmers. Further, there is some evidence of titles being used as collateral for the purchase of consumer items rather than farm inputs.

In 1990 industry provided 63% of total export income whilst agriculture provided only 20%, a fall from 58% of export income in 1980 however, agriculture in 1990 still provided 60% of employment (18.4 million). Further, during the last 5 years per capita GNP has doubled for the country as a whole (19,000 baht in 1985 to 37,000 baht in 1990) whilst domestic rice prices have changed little.

With the population pressure on land, the rapid development of the market economy and growth in industry, the titling of land without other policy initiatives has the potential to cause significant disturbance to social patterns within rural Thailand; it is feared that existing land tax and land use policies are insufficient to provide a framework to support the impact of the titling project.

Land Information

The LTP is significantly improving the quality of cadastral land information available for both in-house land administration purposes and external agency use. It will also provide an easier path to the benefits of any future computerization (Angus-Leppan 1989). The project is progressing province by province and the changes include,

- placing all privately held land on the one register where previously, for the one locality, there were separate registers in different offices,
- placing all title deed parcels on the one cadastral mapping system where formerly there were 29 different datums for title deed maps and a non metric scale map base for NS3K land utilisation certificates and no map base for other tenures,
- decentralizing all documents to local branch land offices where formerly title deeds were held at the central provincial office,
- providing maps on durable drawing film for easier copying and longer life where formerly maps were constructed on paper backed linen and often in poor condition,
- providing up to date cadastral maps and at an appropriate scale for continual updating by the land office where formerly, especially in Bangkok, the maps were up to 20 years out of date
- making available to land offices and Government agencies a valuation role on a block basis in the provinces and on a parcel basis in Bangkok, where formerly there was no independent property valuation information,
- by-products including,
  - densification of the national geodetic framework of survey stations
  - aerial photography and photomaps

This comprises a very valuable source of land information for other land information management projects and policy makers, as well as Government and Private Sector agencies. The key issue is dissemination of the information.

As of 1 January 1992 land offices will use the valuation roll as the basis for calculating the tax payable on land transfers. This will be more equitable than the current system which is based upon the declared sale price. Also it will increase DOL revenue which is already an order of magnitude greater than it's total budget. However, beyond DOL itself there is little evidence of awareness and use of DOL land information. This is an institutional issue, although internal security regulations apply to all maps which forbid making them available to non Government agencies. In the second phase of the project, information systems assistance will help to identify the internal and wider Government and industry efficiency gains that could result from improved access and use of DOL land information.

The further issue concerns maintenance of the new records. Transactions on the subject parcels are suspended whilst adjudication is in progress. At the end of the process all documents, including maps, are filed at the local land office and kept. Except for the copying of the maps, no material is sent to Bangkok. This ensures the register and description of the land parcels are up to date and consistent.

PROJECT DESIGN ISSUES

The LTP was put on a sound footing through a carefully detailed project preparation and design. Important issues addressed in the design included;

- **institutional strength** - at the time of project design the DOL already had several overseas trained staff in divisions targeted for technology transfer. The addition of 1,500 more staff under the project to the existing 10,000 permanent officials and a 30% increase in annual operating budget would not be a limiting factor. About 700 land offices were already established throughout the country.

- **local commitment**- the goals of the project were clearly identified, specified and communicated to all stakeholders; most importantly, the goals formed part of the nation's 5th and 6th 5 year National Economic and Social Development Plans. Total commitment was shown by the executives of the DOL, the Ministry of Interior and resource agencies of Government. Subsequently, the project has continued through 3 administrations (Prime Ministers Prem, Chatchai and Anand) and two coup d'etat (one unsuccessful in September 1985 and one successful in February 1991). The commitment is long term and there are no unrealistic expectations that the project must demonstrate economic gains in the very short term.

- **technical assistance commitment**- the AIDAB commitment to the project has allowed the necessary steps of institutional change to be gradual and well considered; sufficient resources have been provided to permit advisers time to understand the existing situation and institutional culture, time to obtain translations of essential documents and time to assist in bringing about change.

- **legal framework**- the Civil and Commercial Code and the Land Code were well established before project identification. At project start there were an estimated 11.6 million parcels on the NS4 and NS3K land registers (Table 1), and land transfers were routinely completed within 1-2 days. Two vital changes to the Land Code were drafted at the project planning stage and the project was designed with the assumption that the law would be passed in the first year. A bold step perhaps, but necessary to complete the project in 20 years, the first change was to allow the NS3K utilisation certificates to be upgraded to full title deed without a field survey. The second change, to facilitate decentralization of title deeds, was to replace the Provincial Governor as the authorizing officer on title deeds by the Provincial land officer or his branch office head.

- **project scope**- the project includes urban and rural lands. New regulations and practices concerning mapping, surveying and land information apply therefore, to all land under DOL administration. The project includes both the legal and fiscal cadastre; operationally the valuation process up-country benefits from searching the new consolidated land records and conversely, already some land offices are accessing for the first time independent assessments of land values as a comparison with the buyer's declared price. Phase 2 planning has built on these newly formed links and the 10 sub-district land offices of Bangkok and the Central Valuation Authority (CVA) will implement computer assisted operations including digital data exchange of land information commencing in 1992.

Whilst the project design has proven effective, some problems have presented considerable difficulties;

- **institutional**- the simplicity of just one implementing agency is very attractive, as we know all project managers would wholeheartedly agree. The forest encroachment problem, and other related issues such as accusations of DOL improperly issuing documents in forests, could be reduced if RFD input was funded and managed within the project to participate in the adjudication process for the purpose of identifying the forest boundaries on the 1:4 000 photomaps and cadastral maps.

  Secondly, the slow development during phase 1 of the CVA as a "central office and independent agency for the determination of land prices for the use of other agencies" (Objectives of the Fifth National Economic and Social Development Plan 1982-1986) was not anticipated; staff levels are far lower than needed to fulfill it's mission and the valuation legislation which began being drafted in 1985 has not yet been submitted to the Parliament. The CVA remains a division of the DOL and it's work has no legal status. Whilst DOL will benefit from the application of CVA valuations in land office property transfer tax assessments, the major potential beneficiaries would be Local Government. In 1990 USAID sponsored a property tax study with the Department of Finance. It appears now that a broader scope of the tax and valuation issue within the LTP would have allowed direct input from other agencies and thereby possibly have provided a more complete and more persuasive approach to decision makers.

- **legal**- the delegation of title deed authority to the chief land officer has been accompanied with some disquiet; existing practice is that if a mistake is made in a title transaction that leads to the DOL being liable to pay compensation, then the DOL takes action to retrieve the money from the individual officer(s) concerned. Since land prices are high, especially compared to average monthly senior land official salaries of equivalent US$400, great care is taken in handling transactions. Hence, title is not guaranteed by the State. This also has wider management implications in regard to efficiency improvement changes.

MANAGEMENT AND OPERATIONAL ISSUES

Operationally the project has focussed on the surveying, mapping and titling (SMT) in rural and urban lands, which was planned to consume 68% of total project resources. Other operational priorities have been the construction program to facilitate land document decentralization to new or expanded land offices and the strengthening of the CVA.

Before the project commenced, the situation in the SMT activities was;

- no urban improvement programs
- small survey control capability with a few EDM instruments
- low photomapping capability of less than 500 maps per annum
- no map rejuvenation program
- small systematic adjudication capability of about 48,000 parcels per annum (40 teams),
- no in-house computers

The change in position of SMT output capacity within DOL has been through carefully managed change. In summary, the phase 1 results in SMT are shown in tables 2 and 3 below;

OUTPUT	RURAL	URBAN
1 Control Traverse (length in km)	110,000	4,840
2 Satellite Marks (Doppler, GPS)	968	-
3 Photomaps	12,700 [1:4 000]	5,700 [1:1 000]

TABLE 2: Control Surveys and Photomapping Output (6 Years)

Map Compilation Method	Number of Land Parcels [Number of Maps]		
	Scale 1:4000	Scale 1:1000[1]	Total
1 Office based compilation from existing map and plan documents.	586,000 [5,800]	862,000 [7,100]	1,448,000 [12,900]
2 Compilation data from new field surveys and adjudications.	251,000 [maps included in 1]	798,000 [24,400]	1,049,000 [24,400]
Total	837,000 [5,800]	1,660,00 [31,500]	2,497,000 [37,300]

Note 1 : mostly 1:1 000, with some 1:2 000 and 1:500 maps

TABLE 3: Cadastral Mapping Output (6 Years)

The approach taken has been described before; the SMT methodology (Lloyd et al 1991) and technology transfer features (Angus-Leppan 1989). The management of that implementation is of prime interest here.

Change Management

The culture of the DOL has largely determined the approach to the management of change. Clear responsibilities have been delegated to new and existing Divisions without unbalancing the Department. The existing program budgeting process has ensured the effectiveness of activities supporting the LTP and also provided measurable targets to be achieved by each Division. Establishing reasonable levels of efficiency has been approached by firstly, applying principles of minimum change and justifiable change (not change for change sake) and secondly, full technology transfer. In addition, post implementation work flow reviews have been sometimes used to verify pre-implementation plans and assumptions and in one case, map digitizing, resulted in a doubling of overall throughout, improved quality checking, and easier operations.

The staff have accepted the new technology and procedures and emphasis has been given to within Division training. Of both physical and psychological importance has been the construction of the Pak-ret mapping and surveying building which was opened in 1988. The special purpose building contains photogrammetry laboratory, photomap production and development dark rooms, and data processing and digitizing rooms.

Matters that have caused concern at times are discussed below;

- proposed changes in the main business area of land registry operations have always faced healthy skepticism and no significant changes to land office operations have taken place during the first phase, except for the indirect effect of the systematic titling component. Indeed, a slowness to react to land office difficulties in understanding the new procedures, coupled with the pressures of day to day work, has caused the busier land offices to abandon the refiling of the existing documents, and rather than decrease the number of different indexes used to file documents from 4 to 2, there is now up to 5 parcel identifiers (PID).

  The conservatism of people dealing in land transfers is understandable, especially when personal liability is involved. More effort on implementing change in the decentralized land offices is required through education, training and support with respect to the UTM system, new parcel indices, integration of new and existing registers, title deed registration procedures, back-up copy procedures, culling and re-filing. Early in phase 2 a training adviser will assist the DOL to improve the situation.

- Project planning has been based on the individual divisions submitting annual plans consistent with the project design. Insufficient co-ordination of the plans has caused work flow problems such as a shortage of photomaps in late 1990. In response the project has created a co-ordination working group that has made the operational planning top-down and user division driven.

Also of importance is the newly established in-country property valuation course at the Bangkok Institute of Technology. From an establishment of 130 the CVA has 52 BIT graduates and 8 graduates from Australian tertiary institutions. Unfortunately, due to the loss of newly graduated survey engineers to the private sector, the benefit to the project of the excellent Chulalongkorn University survey undergraduate course is diminishing.

Overall, the brain drain to the private sector is a threat to improved performance in DOL and needs to be addressed during phase 2 at the strategic and not only operational level.

CHANGE IN THE ENVIRONMENT

During phase 1 the economic situation in Thailand changed considerably; for example, per capita GNP doubled and the value of exports tripled from 200 Billion baht to 600 Billion baht.

Political emphasis has been given to industrialization and the free market. The following significant changes to the environment that the Department operates in have taken place;

- raising the level of service to the people has become the prime goal of the DOL executive,
- a land sales boom, fanned by land speculation, has given land offices an enormous increase in work load,
- in an endeavor to attract private sector investment especially from overseas, the Government is investing large sums of money in improving the infrastructure in and around growth centres, and this has placed budget restraints on all Departments,
- the rapid increase of economic activity has resulted in a brain drain of survey engineers, surveyors and computer people from the public to the private sector.

The response by the Department has been to increase efficiency through a number of management initiatives and to give top priority to land office operations. Specifically, some initiatives that have changed the LTP include;

- priorities in land titling changed and the industrial zone in the Eastern Sea Board was brought forward to project year 6,
- priorities in the CVA have changed from time to time to provide immediate up to date land valuations to allow the Government to resume land for major infrastructure projects,
- refiling of LTP documents using a new PID has stopped in the busier land offices,
- implementation of computers into Bangkok land offices and the CVA has commenced and will be made operational during phase 2,
- re-allocation of some rural titling staff to urban re-mapping of growth centres, tighter control on manpower allocation and greater use of temporary staff,

- submission to the Parliament of a Bill to create a private sector industry in cadastral surveys (in some areas of Thailand, the delay in subdivision surveys is over 2 years).

PHASE 1 RESULTS IN SURVEYING, MAPPING AND TITLING

In the larger project activities of rural surveying, mapping and titling and urban re-mapping, the results for phase 1 are shown in table 4 and a summary description follows for;

- control surveys
- mapping
- cadastral surveys
- organization and management within the survey, mapping and titling.

More details can be found in (Lloyd I D et al 1991).

Control Surveys

Thailand has a well established primary geodetic network of about 350 stations which is maintained by the Royal Thai Survey Department (Indian Datum 1975) and this datum has been adopted by the Department for further control densification. In rural areas control is placed for two different purposes; control for cadastral surveys of parcel boundaries (especially in villages) and secondly, control for aerotriangulation. In urban centres control is primarily used for aerotriangulation but also, especially in Bangkok, to control the building of a mosaic of the individual survey plans from which the Cadastral Index Map (CIM) is produced. The total control traversing in phase 1 was equivalent to almost 3 circum-navigations of the Globe! In 1990 GPS positioning equipment was put into production to replace the Doppler units introduced early in the first phase.

Mapping

<u>Photomapping</u>

Given that the approach taken to accelerate cadastral mapping is to use rectified photomaps, the quality control and production flow of these photomaps are critical to the success of the project. Over 18,000 photomaps were produced by the Department in phase 1.

<u>Cadastral Map Production by Map Transformation</u>

Cadastral maps on drafting film are drawn as overlays to the photomaps in both rural and urban programs, depicting existing land parcels with UTM grid. No field work is required to draw these maps unless the office records are unreliable. In phase 1 a total of 1.4 million parcels were transformed onto a total of 12,900 maps. A total of 586,000 parcels were transformed from existing NS3K records. A total of 862,000 parcels were transformed from existing title deed maps and plans.

TABLE 4: THAILAND LAND TITLING PROJECT - PHASE I (1985 - 1990) SURVEY AND MAPPING PERFORMANCE

GOALS	PERFORMANCE INDICATORS	TARGET (6 Years)[1]	ACHIEVED (6 Years)
1. Control Surveys Provide survey control on Indian Datum 1975 with UTM coordinates in aerotriangulation blocks and in all villages and urban centres to meet the work progress of the land titling programme.	1. Progress of Major Control Establishment of co-ordinated marks in target provinces;	58 provinces	58 provinces
	1.1 satellite control stations	744 (Doppler)	830 (Doppler) / 138 (GPS)
	1.2 traverse length	18,000 km	22,000 km
	2. Progress of Minor Control Establishment of co-ordinated marks in target provinces;	30 provinces	30 provinces
	2.1 traverse length	87,000 km	88,000 km
	2.2 survey marks	277,000 marks	332,000 marks
	3. Progress of establishment of co-ordinated marks in target urban centres and districts of Bangkok, to support large scale map compilation;		
	3.1 Bangkok traverses	2,440 km	2,620 km
	3.2 provincial urban centres traverses	1,780 km	2,220 km
2. Mapping Provide a uniform series of cadastral maps showing all parcels with title deed tenure, at appropriate scale and with UTM grid, and to meet the work progress of the land titling programme.	4. Output level of 1:4000 scale rectified photomaps over non-forest lands in target provinces.	12,000 maps	12,700 maps
	5. Output level of 1:1000 scale rectified photomaps over major urban centres in target provinces and districts of Bangkok.	3,300 maps	5,700 maps
	6. Number of parcels shown on new 1:4000 scale cadastral maps obtained by transformation from existing 1:5000 (approx.) scale maps in target provinces.	606,000 parcels (n/a maps)	586,000 parcels (5,800 maps)
	7. Number of parcels shown on new large scale cadastral maps (mostly 1:1000) obtained by transformation from existing large scale maps and isolated survey plans in;	919,000 parcels total	862,000 parcels total
Ian L.	7.1 target urban centres provincial	431,000 parcels (2,900 maps)	370,000 parcels (3,400 maps)
	7.2 target districts of Bangkok	488,000 parcels (3,600 maps)	492,000 parcels (3,700 maps)

[1] Targets taken from annual work plan.

3. <u>Cadastral Surveys</u> Provide cadastral descriptions of land parcels by adjudication and cadastral surveys in areas of inadequate documentation, to meet the work progress of the land titling programme.	8. Number of parcels adjudicated, surveyed, marks placed and description recorded on new cadastral maps, over non-forest lands in target provinces; 8.1 parcels on 1:4000 maps 8.2 parcels on large scale maps (mostly 1:1000)	1,016,000 parcels total 310,000 parcels (maps included at 6) 706,000 parcels (n/a maps)	1,049,000 parcels total 251,000 parcels total (maps included at 6) 798,000 parcels (24,400 maps)
4. <u>Organization and Management - Survey and Mapping</u> Strengthen the Department and the Education Institutions to be able to sustain the project for the 20 years and meet the output targets. Ian L.	9. Establishment of re-organised survey and mapping sector with new divisional status for photomapping, map transformation, adjudication and titling functions. 10. Construct a new special purpose survey and mapping building and begin operations. 11. Number of undergraduates in the Chula University surveying course accepting DOL bonds. 12. Chula course structure strengthened by inclusion of cadastral subjects; 12.1 number of cadastral subjects offered	3 new Divisions open in 1988 120 students n/a	3 new Divisions opened in 1988 108 students (23 already graduated) 4 subjects

Cadastral Surveys

Cadastral surveys and adjudication of parcels are occurring systematically in rural areas, province by province, and in step with the other LTP activities. The field documents and completed maps are used to prepare title deeds. In phase 1 a total of 1,049,000 parcels were adjudicated and surveyed. The number of large scale maps drawn from this field data (24,400) was well beyond expectations, reflecting the very many villages that exist in rural Thailand.

Organization and Management

The Organization and Management component, in regard to surveying and mapping, has been very important to control and direct the sudden input of large resources, to co-ordinate the many project activities and ensure the Project is sustainable. Three new surveying and mapping related Divisions have been created within DOL; Photomapping, Land Document Issuance and Urban Mapping. In addition, two existing Divisions have been strengthened and re-organized; Surveying and Computing Divisions.

CONCLUSION

The LTP is a very large project in a developing country and some of the more important issues raised during the first six years of implementation should be of interest to other countries. From the implementation issues discussed in this paper the following conclusions can be made;

- land administration and cadastral projects must link and support broader national land management objectives to be effective and to obtain continued support,

- weaknesses and barriers to success are often caused by institutional problems, not technical nor financial constraints,

- implementation of cadastral change projects is multi-dimensional and success will depend on the skills and attitudes of the people implementing them,

- during the usual lengthy time of cadastral project preparation and implementation the project environment will change and therefore, the implementing agency with it's project control process must be able to monitor key performance indicators in order to permit timely and effective decision making,

- the possible social impact of cadastral change projects should always be considered and preferably monitored during implementation since the repercussions can be considerable on the local community.

This paper has reported the major outputs in surveying, mapping and systematic titling activities of the first phase of the LTP. A total of 1.6 million titles were issued. The results are considerable and a second phase is underway after approval by the Royal Thai Government and with a loan from the World Bank. Technical assistance funded by AIDAB in phase 2 will focus on improving the operations and management of the DOL; in particular, it will focus on strengthening strategic and operational planning, improving monitoring and training, and introducing effective information systems. During phase 2 the annual output rates will increase to ensure the Project finishes the titling of the Kingdom in the 20th year and the four year second phase is planned to output 3 million title deeds.

Interest on this project has been shown from a wide cross-section of the land management community and especially, the World Bank. To the Australian industry it means a valuable pool of experienced experts is available for further projects.

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NATIONAL SPATIAL DATA INFRASTRUCTURES: THE NEXT LIM CHALLENGE

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ABSTRACT

Canada has invested billions of dollars over the last two decades in the development of national, regional, and local spatial databases. Over the next decade the focus will increasingly shift to the construction of a national spatial data infrastructure incorporating these databases into an integrated information highway. This paper will briefly examine some of the major technical, organizational, and policy issues which will need to be addressed.

1. INTRODUCTION

It is a special pleasure and honour to have been invited back to Australia, and to have the opportunity to participate in the Conference on Land Information Management. Australia has become something of a second home for me over the last decade, and I feel privileged to have had the opportunity to see at first hand the pioneering land information initiatives in our two countries.

In these notes, I would like to briefly discuss the next major challenge for the land information community — the construction of our respective national spatial data infrastructures. My comments will be informal, sketchy, and tentative, but hopefully they will help stimulate discussion and debate (for there will be many contentious issues) about a theme which will be taking centre stage in our business over the next few years.

The vision of a national spatial data infrastructure entails incorporating national, provincial, and local databases into an integrated information highway. Such an infrastructure will include not only the databases themselves but also the communication facilities and protocols, the user interfaces, and the institutional arrangements necessary for the effective flow and exchange of spatial information. The infrastructure will include both the horizontal (combining various themes) and vertical (local to national to eventually global) integration of data. This notion of a data infrastructure itself is not new; indeed in many ways it may be considered an extension to the work on regional land information networks that has been underway for the last decade. But it is also leading to a new way of thinking about the nature and role of spatial information, and about the actors and institutions involved in managing the information.

2. BACKGROUND

To provide some context for my discussion, I would like to briefly review land information developments in Canada over the last three decades. The story is very similar to that of Australia in many ways (not surprising given the amount of time we have spent learning from each other), but there are some important differences as well.

From a Canadian perspective, efforts to build computer-based spatial information systems date back to the early 1960s. These efforts have gone through two stages of development and currently are entering a third:

Stage 1(circa 1960-75) saw the first uses of computers in surveying and mapping, the first efforts at automating land records, and the first attempts to build urban and regional information systems; at the same time, the first GIS software was being developed in government labs and universities.
Stage 2 (circa 1975-90) is the period during which computer-based spatial information systems have come into their own for administrative, facilities management, and planning purposes, and one which has witnessed the rapid emergence of commercial GIS and digital mapping software.
Stage 3 (1990 and beyond) is the period we are gradually moving into, in which the focus will be on linking databases together into distributed spatial information networks, on developing application software and decision support tools to more effectively exploit the information available, and on building a much broader information services industry. Overriding this will be a renewed concern about the effective development and management of our land and marine resources, and about relating this to the broader environmental agenda.

Efforts to build parcel-based information systems in support of land administration activities (the area where we have perhaps most closely related to our Australian counterparts) date back to the early 1960s and were related to three separate initiatives: (a) integrated surveying and mapping; (b) land registration reform; and (c) the automation of property valuation records. These themes were brought together in the multipurpose cadastre concept, first effectively thought through in the initial development of the Maritime Land Registration and Information Service. Subsequently it served as a model for the Québec Cadastral Reform Program, the POLARIS program in Ontario, and a number of initiatives in Western Canada. During this same period, increasing pressures to more effectively manage scarce natural resources motivated some jurisdictions to enact legislation which implicitly encouraged the use of more sophisticated inventory and modelling tools for resource management. Several provincial governments and private companies, for example, began building large forest geographic information systems in the early 1980s in support of legislated requirements for detailed long-term timber harvesting plans.

GIS and digital mapping technology have also impacted many other areas. Most large public and private utilities have constructed or are actively considering the construction of automated mapping/facilities management systems. For nearly two decades a number of larger cities across the country (most prominently Calgary, Edmonton, and Burnaby) have been automating their engineering, planning, and emergency services and building records for more than a decade. More recently, much smaller cities and towns (some with populations well below 50,000) have also begun to build integrated urban information systems. GIS technology is also increasingly being deployed in support of environmental planning and monitoring programs.

In this decade, the emphasis is once more beginning to shift, this time toward the integration of these systems into some kind of a network environment. The notion of distributed spatial information networks has been discussed for several years, and a lot of pioneering work on the subject has been undertaken in our country and elsewhere. It is only recently, however, that concrete efforts to build such networks have begun. The reasons for this are at least threefold:
(a) the necessary databases are only now coming online;
(b) the recent advances in communication and distributed DBMS technology are resolving what had been rather serious technical problems; and
(c) there is a growing demand from an increasingly sophisticated user constituency for integrated data sets.

The call for integration is coming from a variety of sources: e.g., the banking community which is beginning to view the automation of property information as an extension of their electronic transfer of financial information requirements (a theme which emerged during the

American Savings and Loan fiasco) and from Environment Canada, which in its recent "Green Plan on the Environment," advocated a national environmental information network.

Building on the need for a common information base, but recognizing the need for independent management of the data by individual agencies and government departments, these information networks are being promoted as a means for linking administrative, environmental, and resource management databases together in order to solve problems crossing functional and geographical boundaries. The Landnet project in New Brunswick, with which I have been associated for nearly a decade, is but one of a number of responses to these demands which are now moving from the planning stages to full scale implementation. Similar efforts are underway in Alberta, Manitoba, and elsewhere, and now we are beginning to see the first tentative steps towards linking these provincial programs together.

Finally, as we move into the 1990s, there is also a growing recognition that these initiatives are but the next stage in an even broader undertaking leading to the creation of a spatial information marketplace (see Figure 1). It has been recently estimated that North Americans are already spending more than $4 billion per annum in the spatial information field, and that by 1992 more than $600 million will have been invested in hardware and software alone [Champlain Institute, 1990].

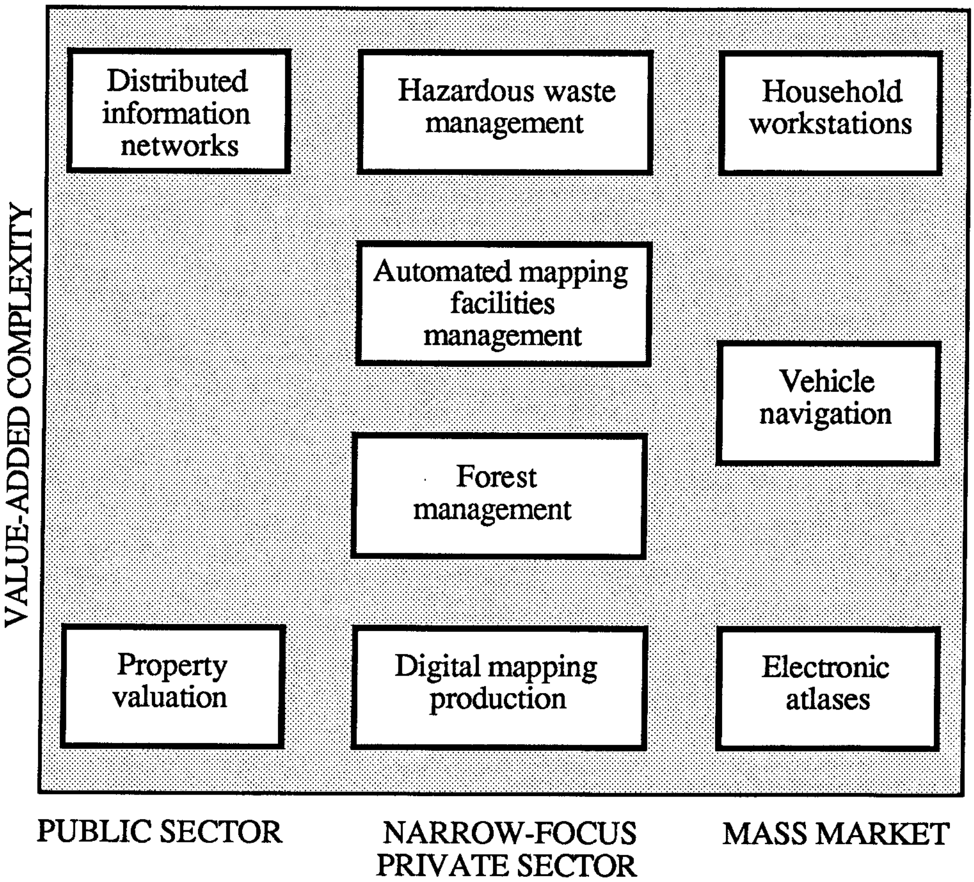

Figure 1. Spatial information marketplace.

3. THE TECHNICAL CHALLENGES

The construction of a national spatial data infrastructure has been compared to the building of the transcontinental railway system across Canada. It is viewed as an immense undertaking, full of new and difficult challenges, requiring levels of cooperation and a visionary spirit seemingly beyond current capacities. The technical challenges in building such an infrastructure largely relate to the telecommunication requirements, the problems of coping with a hetereogeneous database management environment, the need for a new generation of simple but powerful access tools, and the requirements for standards.

The telecommunications requirements should not pose a major technical problem. Local area-regional-national backbone network facilities are currently available throughout much of the country, providing relatively high bandwidths, flexible topologies, and multiple link redundancies. Multi Megabit per second capabilities will routinely be available by the mid-1990s. These facilities should comfortably handle anticipated estimates of demand for spatial data [Brackley and McLaughlin, 1991]. There are, however, important concerns related to the organization of these networks, to the projected tariffs and regulatory practices which will need to be addressed.

A more serious concern relates to the complex hetereogeneous DBMS environment within which integration will have to be effected. For all the impressive efforts that have been made in linking databases to date, most of these networks still represent loosely-connected collections of systems. The ready integration of graphical and textual data from different systems is still difficult in a network often consisting of hardware and software from many different vendors. As Richard Pollock and I noted in a recent paper, current operational database management technology is restrictive in its capacity to clearly model and manage complex data objects in general, and spatial data objects in particular [Pollock and McLaughlin, 1991]. While distributed DBMS technology has been commercially implemented, it has largely been developed in the context of the relational data model and has limited applicability to the management of complex spatial data. Webster [1988] presents a framework for examining distributed spatial databases and discusses recent initiatives to solve the problems using existing DBMS technology. It will probably not be until at least the end of the decade, however, before truly heterogeneous spatial database environments are realized (see Figure 2) [Lee and McLaughlin, 1991].

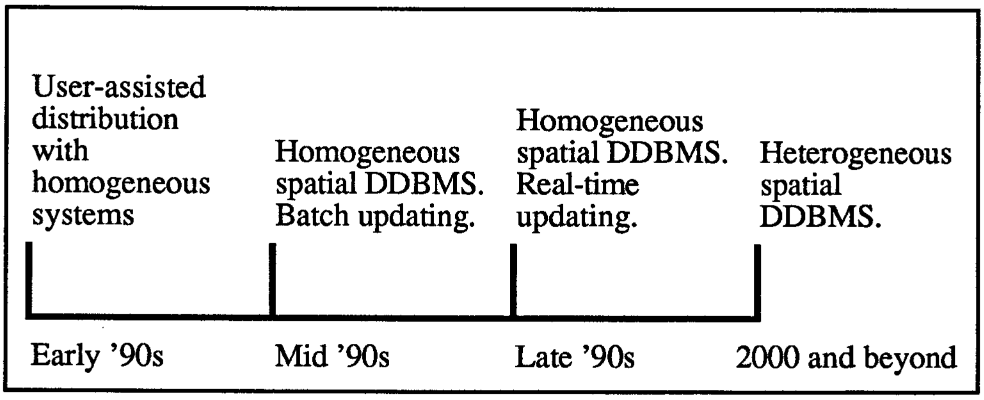

Figure 2. Distributed spatial DBMS developments.

4. THE STANDARDS ISSUE

An especially important challenge will be the development and acceptance of appropriate infrastructure standards. If the recent history with data interchange standards is a guide, it will also prove to be an especially difficult one. The story of attempts to develop generally recognized interchange standards covering data organization, feature classification, quality and reliability dates back at least a decade and does not make for encouraging reading. Lee and Coleman [1991] provide an informative review of the problems which have had to be addressed and the complications which have arisen. While the potential benefits of such standards have been widely recognized, they have also required acceptance of a variety of

To effectively address this dilemma, there must be a reassessment of what has been considered as relatively 'unchanging' in terms of data specifications and user design requirements. The information management community must identify the concepts, constraints, and specifications which have become *de facto* standards by virture of their long-standing acceptance, and then determine if these are indeed still valid in today's application-driven environment. Once this is accomplished, the appropriate processes and institutions required to formalize these standards must be reassessed and may have to be modified to meet changing needs.

Finally, as with political leadership, one must keep in mind that status as a 'true' standard can only be conferred by followers. As a community, we must recognize the formidable task to be faced in agreeing on workable and robust standards if we are to effectively move on to the next generation of land information management challenges.

5. ORGANIZATIONAL STRATEGIES

The database development initiatives of the past two decades have been largely orchestrated within traditional public agencies, typically a resource management, land records, or surveying and mapping department. Usually the focus was limited to addressing internal requirements (e.g.,the history with forestry); in a few highly publicised cases (such as with L.R.I.S.) there was a mandate to serve a broader constituency. More recently, a web of formal and informal linkages (through a variety of interagency and intergovernmental committees) have evolved to provide at least a modest level of coordination and policy input.

Increasingly, however, new organizational arrangements are being put into place as the notion of a data infrastructure begins to take hold and especially as some of the economic and social implications begin to be appreciated. Central government agencies, especially at the provincial level, have become increasingly involved in the field in terms of: (a) policy formulation and implementation; (b) network management; and (c) industry development. Efforts are also underway to construct new arrangements for coordinating activities between the various levels of government and for involving the broader community. This is not happening without difficulty, however, as reflected by the very different priorities of the corporate information officers, the resource managers, and the industrial development agencies.

Probably the most interesting recent developments relate to program delivery (see Figure 4). As described by Donahue [1989], there are a variety of options for providing public services. Two of the more innovative and potentially instructive models for the national spatial data infrastructure are the crown corporation set up in New Brunswick for managing geographic information and the strategic alliance between the public and private sectors in Ontario to build and manage their automated land registration system.

The New Brunswick Geographic Information Corporation was established in 1989 as an independent Crown corporation reporting to a Board of Directors but wholly owned by the provincial government. This Corporation has been given responsibility for coordinating land information policy in the province, developing the provincial land information network, and assisting in developing a provincial spatial information industry. As well, it has been given line responsiblity for land records activities (bringing under its umbrella registry, assessment and surveying and mapping functions for the province).

Real Data Ontario Inc. (RDO), a company jointly owned by industry and the Province of Ontario, was formed in 1991 to complete the construction of the automated land registration and property mapping program in the province (referred to as POLARIS in the literature) and to market the resulting products and services. In my presentation, I shall discuss some of the potential strengths and limitations of each of these approaches and will also examine some other organizational arrangements which will be required from a national perspective.

	Collective payment	Individual payment
Public sector delivery		
Private sector delivery		

Figure 4. Dimensions of the public/private choice (from Donahue [1989]).

6. POLICY CONSIDERATIONS

While the technology and systems engineering challenges associated with building a national spatial data infrastructure will be significant, there is no doubt that the more fundamental policy and social issues will prove to be the dominant concern. These range from concrete economic concerns about how the development and management of an infrastructure is to be financed, to such legal concerns as data ownership and responsibility, to much broader social and political issues.

There are a host of economic concerns related to the construction and management of a national spatial data infrastructure. The major issue being heatedly debated currently, and for which there is as yet no concensus, relates to pricing strategies for information products and services. The federal government, many GIS vendors, and others are forcefully arguing for the retention of the token price approach to public information (basing their case largely although not exclusively on the double taxation and public access to information arguments); increasingly, however, there is a strong case being made by the provinces and some local governments for the introduction of more market-oriented pricing strategies (basing their case on the need to efficiently allocate scarce resources and also, perhaps ironically, on the public access to information argument).

Finally, I hope also to briefly consider some of the still broader and ultimately more basic social and political issues which are just now beginning to be addressed in any meaningful fashion. These include such questions as who should be involved in the information process (central and local governments, private industry, individual citizens), how information products and services should be financed, how the information process should be controlled, and so forth. There are also very real concerns about privacy and security, the proliferation of information files and, perhaps above all else, the nature of individual and collective participation in the emerging information society. Many of these issues have been brought together in the emerging debate over rights of access to public records — perhaps the paramount social issue in any initiative to build a national spatial data infrastructure.

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ECONOMICS OF LAND INFORMATION MANAGEMENT

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ABSTRACT

This essay is designed as a follow-up to the paper by McLaughlin and Wunderlich presented at the Regional Seminar on Land Information Systems in the Pacific Rim in Kuala Lumpur in 1987. An effort is made in this paper to document the changing environment of land information management while addressing economic issues such as benefits, costs and pricing strategies within this context.

1. INTRODUCTION

This presentation is designed as a follow-up to the paper by McLaughlin and Wunderlich given to a Regional Seminar on Land Information Systems in the Pacific Rim in Kuala Lumpur in 1987. In that paper an effort was made to examine: (a) the nature of information as an economic resource; (b) the measurement of the costs and benefits associated with land information systems; (c) the development of pricing strategies for information products and services. While addressing these same themes, we will also attempt in this paper to place these economic issues within the context of a rapidly changing environment.

As we will briefly describe in the next section, the land information business in North America is undergoing a fundamental structural change. On the one hand, Governments are starting to take the notion of information as a strategic resource seriously and are beginning to make major investments in information infrastructure; at the same time industry is beginning to appreciate the commercial potential of these information resources. To understand these developments, we will begin with a little bit of history.

2. BACKGROUND

North American efforts to build computer-based land information systems date back to the early 1960s. These efforts have gone through two stages of development and currently are entering a third [McLaughlin, 1990]:

Stage 1 (circa 1960-75) saw the first uses of computers in surveying and mapping, the first efforts at automating land records, and the first attempts to build urban and regional information systems; at the same time the first GIS software were being developed in government labs and universities.

Stage 2 (circa 1975-90) is the period during which computer-based land information systems have come into their own for administrative, facilities management and planning purposes, and one which has witnessed the rapid emergence of commercial GIS and digital mapping software.

Stage 3 (1990 and beyond) is the period we are gradually moving into, in which the focus will be on linking databases together into distributed land information networks, on developing application software and decision support tools to more effectively exploit the information trade-offs [Exler, 1990]. As well, efforts to reach concensus on national data exchange standards have been slowed by having to contend with different interest groups promoting the adoption of competing rather than complementary suites of standards.

The challenge becomes more daunting when one considers the wide variety of standards which will have to be considered in the construction of the national infrastructure, as described in Figure 3 [Coleman and McLaughlin, 1991]. Agreement will be required on standards for hardware and communications, software, and data specifications and format. This will entail not only an indepth understanding of the technical issues at stake, but also new approaches to the standards process itself.

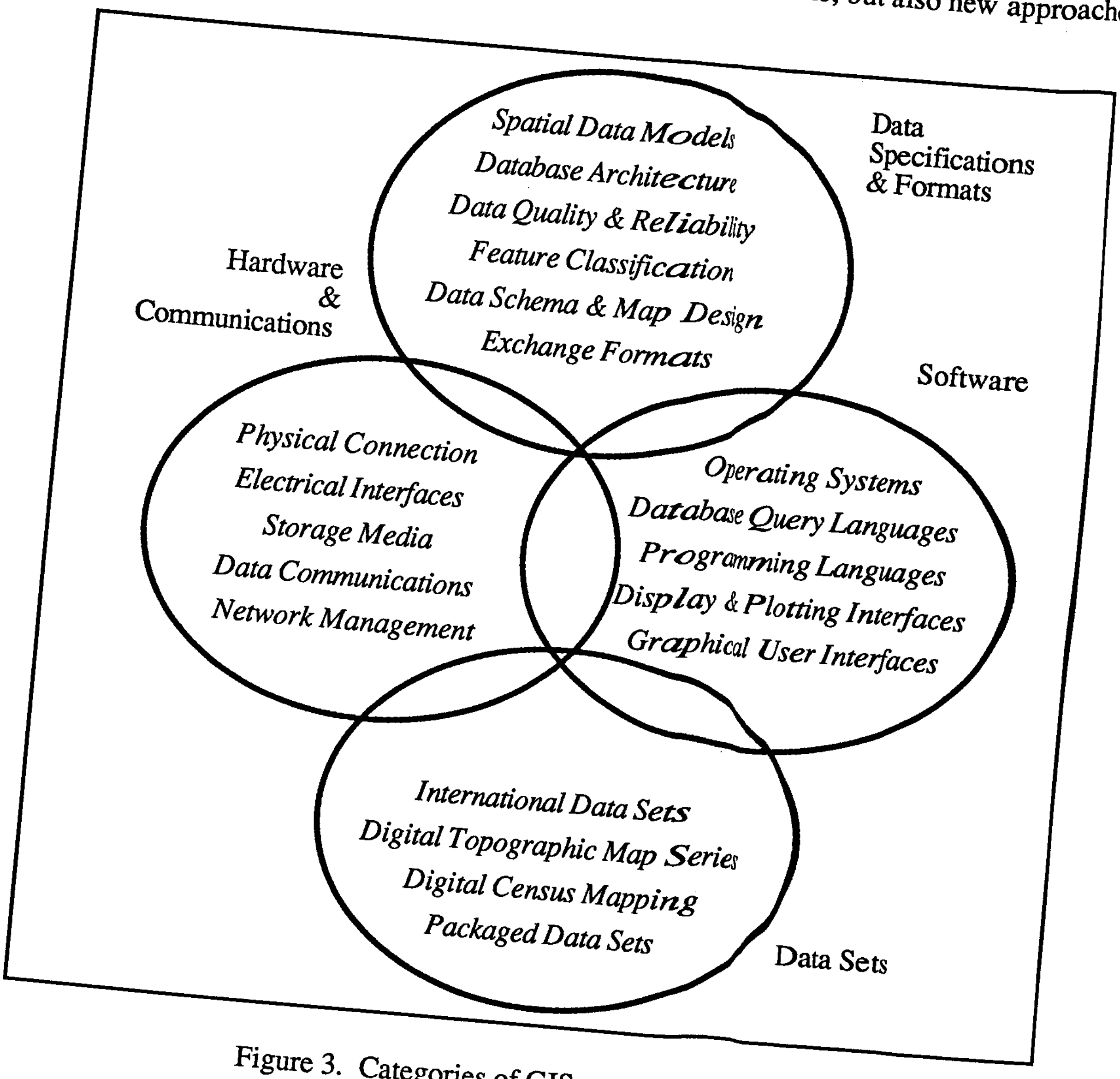

Figure 3. Categories of GIS standards.

Dave Coleman and I have argued in this regard that, given the poor track record to date, the time has come to reexamine the procedures involved in developing, adopting, and implementing spatial information standards. Improvements to hardware and software standards will always exert a major influence on our own requirements for data specification and format. New candidates for these 'lower-level' standards will be introduced even more rapidly in the future. The questions that need to be addressed include: How can we shield the general user community from such rapid changes, yet make sure that our standards are not tied to obsolete technology? Can we afford to redesign our geomatics standards every 5-10 years to deal with these changes? Are the processes and institutions involved in standards assessment and recognition still adequate?

available, and on building a much broader information services industry. Overriding this will be a renewed concern about the effective development and management of our land resources, and about relating this to the broader environmental agenda.

Much of the interest and activity in the land information field has been driven by revolutionary changes in the tools for positioning and acquiring spatial data, for analyzing and managing this data, and for integrating and disseminating the resulting information products. As a new generation of microcomputer-based mapping, spatial analysis and decision-support tools is coming to market, this interest is quite literally exploding. At the same time, however, it has been the less glamorous effort of building and maintaining the necessary digital databases which has consumed most of the available resources. Now, moving into an increasingly data rich environment, emphasis is shifting to the institutional arrangements necessary to underpin this infrastructure and to support the wide range of potential applications of these databases.

These developments are being accompanied (and are increasingly being driven) by changes in user requirements. Some of the trends include:

(a) changing requirements for land-related information (increased focus on integrated resource development and management; renewed concern about the environment; recognized need to view development from environmental, economic and institutional perspectives);
(b) growing awareness of the costs involved in gathering and managing land databases, and a slowly emerging appreciation for the importance of treating information as a corporate resource; and
(c) growing sophistication of the user community (both in terms of technical literacy and in terms of potential role of information in the decision-making process).

All of the above developments are being accompanied by an increasingly crowded policy agenda, in which a wide array of issues is being heatedly debated and a number of innovative approaches to organizing and managing the land information business are being proposed.

3. ECONOMIC ANALYSES

In recent years the vast majority of economic analyses associated with land information activities has focused on the procurement of tools such as geographic information systems (GIS). Typically, acquiring a GIS is initiated by attempting to define user requirements in support of activities, defining specifications necessary for the proposed products and then matching these needs to the performance criteria of commercially available software. A broad brush estimate of benefits, usually in the form of labour/time savings and costs reduction, is generally compared against the initial capital outlay, data capture/conversion costs and projected ongoing operational and maintenance costs associated with implementing a GIS (see figure 1). A consulting industry has emerged to perform these analyses and various methodologies have been introduced (usually adapted from the MIS and/or accounting fields).

Much of this bread and butter consulting work has focused on justifying systems requests and on addressing the question of what type, size and configuration of hardware//software is required to perform an organization's functions more efficiently. A number of proprietary tools have been designed to assist with these evaluations and several consultants have developed databases rating the performance of various commercial products. However, due to project confidentiality and differing requirements for map and attribute data, and due to significant differences in the styles and competence of the evaluators, the resulting recommendations still vary significantly from one jurisdiction to the next.

Methodologies are also being developed which attempt to take a more corporate-wide focus by accounting for the impact of new information technologies on cost savings and revenues in other areas of an organization's activities. In addition, emphasis is beginning to be placed on identifying new products and services, together with some assessment of the markets that the organization may be serving in the future. In this regard a number of tools used in traditional market research (especially the use of focus groups) are increasingly being deployed.

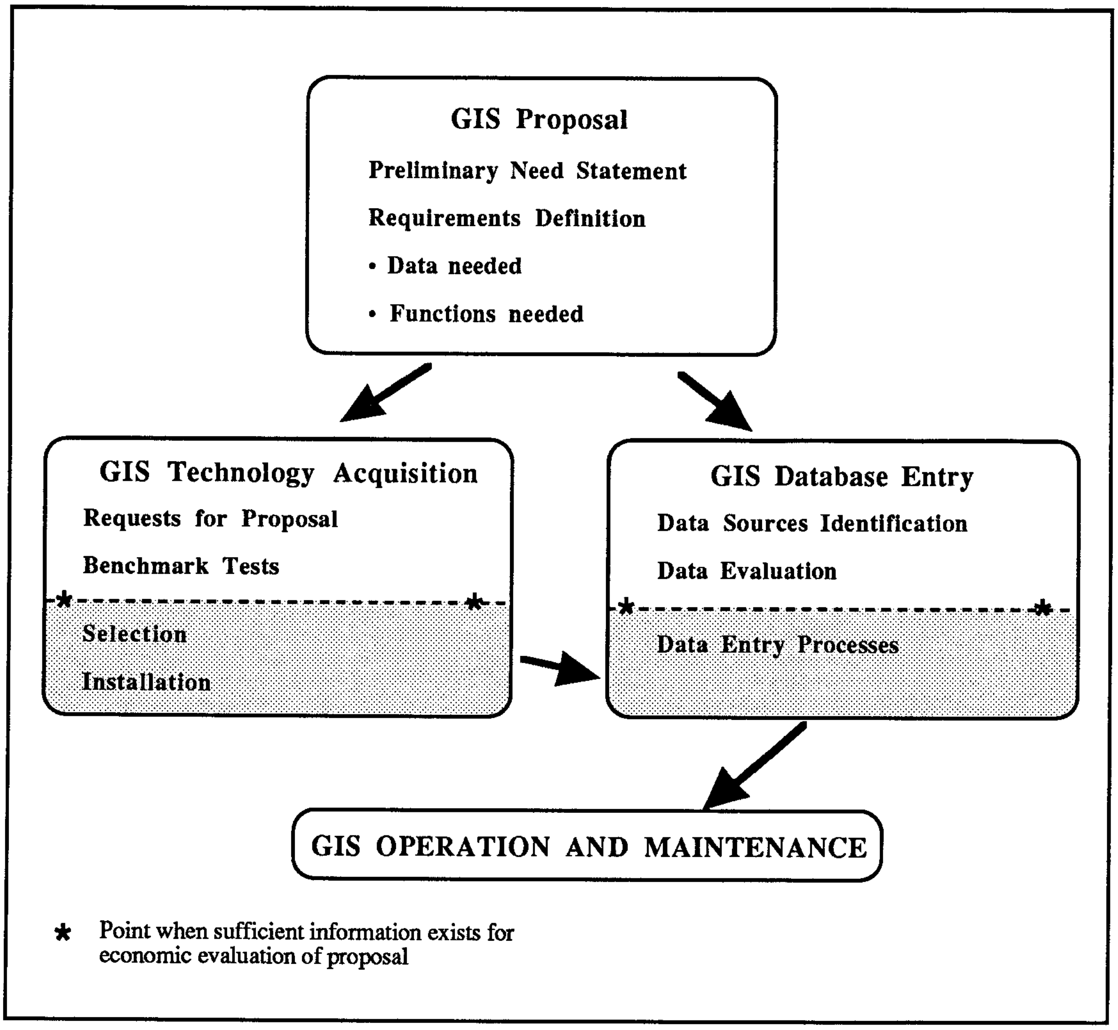

Figure 1: GIS Implementation Process [Dickinson and Calkins, 1988]

Efforts to actually document user requirements for information products and services have generally been based upon some derivative of two basic approaches: (a) the generic user need approach; or (b) the mandate vs. information requirements approach. The generic user need approach has been favoured by vendors and is widely employed in the procurement studies. It entails defining the generic tasks that the client perform, the generic types of data required for these tasks, and the generic types of reports and/or analyses required as a result of these tasks [e.g. Dangermond and Freedman, 1983]. Many of these requirements can then be matched with specific capabilities of relevant information technologies to assess how they would/would not facilitate the tasks at hand. In the mandate vs. information requirements approach, emphasis is placed not on the flow of the data, but rather on the types of information required to fulfil a given mandate. Although still assuming an *a priori* requirements framework, this approach can provide a much deeper understanding of the real requirements for and applications of information. However, it can be an expensive and time-consuming process and there are few good examples of such studies to date [a seminal example is found in Nichols, 1987].

Comprehensive program analyses using traditional benefit-cost techniques are still sometimes employed, although many of the difficulties associated with such techniques are still prevalent. These include: (a) difficulties in documenting indirect and future costs and benefits; (b) discounting difficulties; (c) difficulties in assigning intangible benefits and costs (although there are any number of strategies based upon modified Delphi procedures currently employed); and (d) distinguishing between public and private responsibilities. Perhaps the most important difficulty, and the one alluded to at the outset of this paper, relates to the problems of trying to predict future benefits and costs when one's basic reference framework (values, priorities, notions of public goods, etc.) are in flux. In the early days of building computerized land information systems, when providing basic public service was clearly the *raison d'etre*, such analyses were invariably a prerequisite [Larsen, 1972]. Increasingly, however, these undertakings are viewed as providing the infrastructure for the evolution of a spatial information marketplace and a much more market-oriented approach to product assessment is being taken (entailing risk assessments, return on investment calculations, etc.). This is an important theme and one which will be more fully developed in the oral presentation.

A related topic of growing interest is the use of retrospective assessments, i.e. reviewing the economic benefits and costs, social impact, etc. of programs well along in the life cycle. This is a theme which we have talked about for some time in the abstract, but only recently has a detailed case literature begun to appear. One of the earliest examples of such assessments was a study on the land survey system of Western Canada [Moore, 1978]; a more recent example would be the review of the role and impact of information technologies in the U.S. Forest Service over the period 1974-1990 [Healy and Ascher, 1990].

4. DOCUMENTING COSTS

The problems of documenting costs have received increasing attention in recent years. Considerable material is now available concerning the specific costs of acquiring hardware/software and of building databases (although it often requires careful interpretation); some documentation is beginning to be released which provides a more comprehensive assessment of building and managing computer-based land information systems.

The general story with respect to hardware and software of course is well known. Over the past three decades, there have been substantial changes in the cost, architecture and performance of computer processors. The distributed computing trend of the 1980s with the advent of intelligent workstations, has seen smaller, less expensive but powerful computers being organized into local area and more extensive networks – providing greater access to more computing resources and databases. The past decade has seen a dramatic increase in performance/cost ratio of computer processors (with processor performance referring to the overall efficiency of a processor and includes characteristics such as speed of instruction processing and efficiency of input/output tasks) [Croswell and Clark, 1988]. For example, the forest management information system in the province of New Brunswick upgraded its GIS from a mini-computer based system to a minicomputer and workstation based configuration to accommodate an expanding number of applications, users, and increasing volume of data. Table 1 illustrates the initial costs of the original mini-computer based system to the upgraded configuration [Dick, 1991]. *[Cdn.$ 1 = approximately US$ 0.86]*

At the same time that hardware costs have decreased dramatically, programmer salaries and other staff costs have been increasing. As systems have become more complex, more personnel have been required to develop and maintain the software, thus increasing software development costs. It is generally conceded that software costs will continue to rise at least in the near term for two reasons: (a) the trend towards increasing systems complexity shows no sign of abating soon; and (b) users are continuing to place an increasingly higher demand on program performance. And it seems clear that as hardware specifications become more standardized, users will base their decisions more heavily on software performance when choosing a system [Lee and Zhang, 1989].

	Mini-computer (1982-83)	Mini-computer (1989)	Workstation (1989)
CPU			
MIPs	0.7 per unit	4 per unit	12 per unit
Cost	$200 000	$342 000	$100 000 for 5 units
AGGREGATE STORAGE	$96 000 (900 MB)	$130 500 (3 GB)	$34 000 (1.4 GB)
LAN			
Server	N/A	$14 000	$115 000 (16 MIPs)
PLOTTER	$90 000 (1 unit)	$53 000 (1 unit)	N/A
TERMINALS	$82 500 (4 units)	$36 000 (3 units)	N/A
SOFTWARE	$89 000		$87 000 (5 site licences) $25 000 (DTM Module) $7 000 (network software)

Table 1: Comparison of Mini-computer and Workstation Configuration for the Timber Management Branch GIS, New Brunswick Department of Natural Resources and Energy [Dick, 1991].

Turning to the costs of building databases, these can be thought of in terms of initial 'lift' or mapping costs, conversion of graphics information costs, and textual data entry. In a typical land information automation program, these will form the largest implementation costs, dwarfing initial hardware and software acquisition costs [Jordan, 1990], particularly when base maps depicting topography and attribute information are not available digitally. As an example, we have reviewed the costs associated with building a comprehensive forest management information system for the Province of New Brunswick. Although initial hardware and software costs were substantial (Cdn.$750 000), more than Cdn.$6 million were subsequently expended over four years (1982-1986) to build the forest information database [Dick, 1991]. Table 2 shows in further detail the components of the database building activity.

ACTIVITY	COSTS (in Millions)	TOTAL COSTS
INITIAL ACQUISITION (1982) Hardware/Software (mini-computer-based system, includes training costs)	$0.750	$0.750
System Acquisition Costs		**$0.750**
DATABASE BUILDING (1982-86) i) Aerial Photography of Province (1982-85) ii) Photo-interpretation • Interpretation • Field Quality Checks iii) Conversion • Digitization & Edge-Matching • Base Map Costs • Professional Staff Time	$0.800 $1.650 $1.500 $0.950 $0.250 $1.200	$0.800 $3.150 $2.400
Total Database Building Costs		**$6.350**
UPGRADE (1989) i) Hardware ii) Software iii) Training/Consultant/Maintenance	 $0.820 $0.120 $0.075	 $1.015
Total Upgrade Costs		**$1.015**
ANNUAL OPERATING COSTS i) Hardware/Software Leasing & Maintenance ii) Database Update & Maintenance iii) Application Development iv) Administration	 $0.532 $0.135 $0.120 $0.050	 $0.837
Total Annual Operating Costs		**$0.837**

Table 2: Acquisition and Implementation of GIS Costs at the Timber Management Branch, New Brunswick Department of Natural Resources and Energy [Dick, 1991].

In the above example, the cost of mapping the province of New Brunswick averaged approximately Cdn.$3 900 per map sheet over a five year period from 1985 to 1990. The digital maps are compiled to specifications where 90% of well-defined features are mapped at spatial accuracies of 2.5 m from 1:35 000-40 000 scale aerial photography and presented at a nominal scale of 1:10 000. This cost includes all activities related to map compilation (flight planning to cartographic editing and distribution), support, equipment and overhead. The map compilation component makes up 75% of total costs. The costs of this initial compilation is not likely to decrease much further unless users are prepared to accept less data content, less stringent spatial accuracies and the advent of a technological breakthrough in compilation processes that require human resources [Pearson, 1991]. While these costs are illustrative, it must of course be recognized that digital mapping costs varies widely from one jurisdiction to another. Costs are influenced by the nature of the terrain, specifications of the mapping (including spatial accuracy and data content), and competition among mapping firms if the mapping activity is contracted out.

Digital property mapping costs have also been subjected to fairly close scrutiny. A study conducted by BSI Consultants in the United States in 1989 determined that US$4.00 per parcel was an average cost for urban property map conversion. This price included entering parcel text, utility network, street boundaries and centerlines, street names, parcel boundaries, symbols and map legend. The final product consisted of topologically structured and edge-matched data in a specified data interchange format [Parent and Finkle, 1989]. In the Maritime Provinces of Canada, the consensus among companies that provide data conversion services is that the cost of converting paper copy property maps to digital format is approximately Cdn.$5.00 to $6.00 per parcel. This cost also includes topology building, edge-matching, data cleaning, and building the databases to create a final product that meets established specifications. These service firms are of the opinion that they are now at, or near, the top of the learning curve and believe that learning is no longer a significant factor in cost reduction [Champlain Institute, 1990]. Ingersoll [1990] discussed recent technological advances such as automatic recognition and vectorization that may impact the costs of utility mapping conversion.

The problems in providing a more comprehensive understanding of the costs associated with building and maintaining land information systems have been recognized for some time. These include: (a) the significant variations among and within jurisdictions resulting from differences in the physical and economic geography, in the nature and complexity of the land tenure arrangements, in the structure and content of the existing information infrastructure, etc.; (b) the lack of adequate financial reporting systems; (c) the difficulties in reconciling costs among various departments; (d) the problems in tracking maintenance, life-cycle, overhead and training costs [McLaughlin and Wunderlich, 1987]. However, these problems are being tackled. As traditional public agencies are forced to become more market driven (either through cost recovery mandates or through some form of privatization), they are finding it essential to develop more comprehensive cost accounting systems. A number of programs have been underway for sufficient periods (such as the New Brunswick forest management example above) that they are now being subjected to detailed audits.

Salaries, maintenance costs, etc. have also been coming under scrutiny. Salaries and related costs have increased dramatically over the last decade and are likely to continue to outpace inflation for at least the next two years. There is still a marked shortage of technologists and managers due to the increasing demand from software and system vendors, all levels of government, and utility organizations.

Maintenance costs include hardware and software maintenance, database maintenance, staff, overhead, and supplies. Jordan [1990] suggests that annually, hardware and software maintenance costs form the largest expense (amounting to 68% of annual operating costs) as in the case of the New Brunswick forest management GIS implementation. Refer to Table 2 for further details on annual operating costs. In the case of digital topographic mapping in New Brunswick, 25% of total costs is spent on database maintenance activities such as archiving. Database maintenance costs is a function of the dynamics of organizational activities – the cost of maintenance being proportional to the frequency of data update. At the technological level, database maintenance will likely decrease as technology for storage and analysis becomes cheaper. Further, as external government departments increase the use of GIS systems and the map database, information collected by these users for their own purposes may be transferred to the mapping agency for incorporation into the mapping database. Finally, along with the trend of increased processor performance, there has been the reduction in physical size of computers. This has meant a decrease in environmental controls and space needed to operate them. Space requirements for housing computers have decreased five times since 1980. Environmental and maintenance limitations have also decreased greatly since the 1970s [Croswell and Clark 1988].

5. DOCUMENTING BENEFITS

With important exceptions, little has been done to formally account for the benefits associated with implementing GIS technology. Experience in the software engineering field in the U.S.

indicates that costs of such record keeping would run to about two to three percent of the total cost of the project [Tomlinson, 1987]. The perceived benefits from GIS systems are often accrued from increased productivity and effectiveness and improved decision making. The traditional method of identifying such benefits has been by estimating reduction in labour and time in accomplishing organizational mandates with the use of a GIS. The time savings do not necessarily translate to reduced labour costs; often personnel resources are reallocated to perform other functions that were neglected (due to time constraints) or present operations that have expanded. Nevertheless theoretical assumptions are often made by consultants and vendors to justify a procurement. A typical approach will be to consider that the unit product of a GIS is processed information, usually in the form of a table, list or map. The benefit of a unit output (as an item of information) is then assessed by comparing the outcome of decisions made using it and also decisions made without it. In almost all circumstances, both such outcomes would have to be estimated based upon rather crude assumptions [Tomlinson, 1987]. Moreover, it is also difficult to attach a value to the ability to share information across departments which remains one of the major benefits of GIS implementation.

Nevertheless a variety of methodologies have been constructed to tackle the problem. Cross [1990] for example has developed a strategy for examining three benefit factors: time savings, resource reallocation and improved decision making, arguing that the quantity, product range and character will change significantly with the use of a GIS. Time savings is estimated by assigning a percentage of each activity that will be made more efficient by the use of a GIS. The proportion of time saved is estimated by professionals familiar with the functionality of a GIS. This savings in time plus an estimate of how each function can be improved further, is translated to dollar values.

While the value of large data processing systems is primarily its capacity to substitute computer power for routine labour, the value of geographic information systems is also perceived to lie in its power to improve professionals' performance. The argument presented is that time saved through automation of routine tasks, frees up time to be spent in performing more valuable work resulting in increased effectiveness. Cross [1990], for example, has suggested that managers and professionals spend an average of 61% of their time on higher value activities for which they have been paid, and 39% of their time on clerical and other lower value tasks. Resource reallocation refers to this shift in an employee's time due to GIS implementation.

Improved decision making which includes reduced risk and uncertainty is most difficult to quantify. Judgmental estimates of value has to come from the decision makers. To improve the accuracy of these judgements, decision makers are informed about the potential use of GIS products. Dickinson and Calkins [1988], amongst others, have proposed a method whereby the result value of a decision is subjectively determined and the perceived contribution of GIS model:

Benefit = GIS contribution x (decision making contribution x value of result)

Another method of estimating benefits of improved decision making is to determine the costs of having the information necessary to make the decision done by a professional service. Another important variable is the frequency with which such decision support is required by the decision makers. Estimates of demand for GIS products is usually conservative due to the uncertainty of how a GIS could contribute to the process [Cross, 1990].

The Nordic Kvantif II project [1990] represents an example of the trend towards assessing and interpreting market demands for land information products. In this project, possible actors, both direct and indirect, in the market were identified. Conjoint analysis [Green and Srinivasan, 1978] was used to identify attributes relevant to customers in forming product preferences and from this process an estimate of the utility/benefit of the product was determined. A product matrix was designed to incorporate attributes considered important to customers. Price was included as a product attribute and in this way, user preferences can be transformed into monetary units expressing a willingness to pay for each product level.

6. PRICING STRATEGIES

Another economic issue which has now become a major concern is the development of pricing strategies for land information products and services. A full scale debate is now underway on this subject. While there remain many advocates for retaining the token price approach to public information (basing their case largely although not exclusively on the double taxation and public access to information arguments), there is an increasingly stronger case being made for the need to introduce more market-oriented pricing strategies (basing their case on the need to efficiently allocate scarce resources and also, perhaps ironically, on the public access to information argument). Underlying the debate have been changing notions about the idea of information as a public good (for a recent tutorial on the public goods arguments, see *The Economist,* February 23, 1991, pp. 72-73).

For those organizations moving to a market-oriented philosophy, at least three general strategies for price determination are being considered:

(a) cost based pricing, where prices are set largely on the basis of the fixed and variable costs of their production and handling;

(b) demand based pricing, where the price is based on what people are actually prepared to pay or on what is perceived as the value of the product; and

(c) competition based pricing, which depends on what other producers of the same product or service are charging [McLaughlin and Wunderlich, 1987].

Competition based pricing is becoming increasingly important as a variety of commercial information brokers are entering the marketplace.

Most public land information agencies in Canada and the United States currently recover only the costs of reproduction and distribution of their land information products and services. However, several jurisdictions, are beginning to look seriously at new pricing strategies. A recent study undertaken by the province of British Columbia, for example, recommended a compromise of the three approaches discussed and has promoted a partial recovery scheme. If adopted by the province, it will involve assessing the full costs of producing land information products and then apportioning some pre-determined portion of these costs to users. The study contends that this approach is particularly relevant to pricing land information where a portion of total demand can be assigned to non-government users. However, it is acknowledged that in the absence of the known demand, the costs assignment to non-government users may be arbitrary and may reflect political sense more than financial or economic logic. The objective of the partial cost recovery model is to "charge users with a fair proportion of the total costs of the service which at the minimum reflects the incremental costs of providing the service and at the maximum reflects the market's view of the value of the service" [LISC, 1990]. The general principle of the approach requires that clients, as a group, pay a share of:

(a) a capital cost component reflecting the costs of database creation, amortized over the life cycle of the database (e.g. annual costs of the use of the database such as depreciation and financing);

(b) an operating cost component, reflecting the ongoing costs of maintaining and updating the the database (e.g. wages, data processing, and administration); and

(c) an incremental cost component reflecting the costs of providing the service or product which would not be incurred if it were not sold.

The share of the capital and current costs may vary between 0% and 100% while the share of the incremental costs assigned to users should always be 100%. Demand is then estimated to determine unit price of the products. Market and demand information will be monitored in the meantime to adjust prices when necessary as time progresses [LISC, 1990].

The B.C. study also recommended limited use of differential pricing; the rationale being that a multi-price system is difficult to administer and may be open to potential abuse. However, special cases arise whereby arguments can be made for prices above or below the set price. Examples of such users are other provincial government users, other levels of governments and special interest groups (e.g. academic institutions). Differential pricing can also apply in cases when multiple sales are made to the same customer, cost sharing arrangements with specific clients have been agreed upon, updated data sets are to be distributed, and distributed data are to be used for economic and technological gains for the province. In strict economic terms, differential pricing can be applied when there is a case for quantity discount pricing with price breaks at pre-set volumes or when orders are of sufficient quantity that a saving may occur in incremental distribution costs [LISC, 1990]. This study and proposals from a number of other North American jurisdictions will be discussed more fully in the oral presentation.

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PILOTING AN IN-HOUSE TRAINING PROGRAM IN LAND INFORMATION MANAGEMENT

A Case Study - South Australian Department of Lands

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ABSTRACT

The role of the department is changing to meet the needs of an expanding market for land information services. In line with its business plan, key operations are being commercialised and a more corporate approach to service delivery has been adopted.

These initiatives require that selected employees be equipped with multi-disciplinary skills, to fulfil their future role as Land Information Managers.

Whilst there is an ongoing dialogue with tertiary education authorities to develop suitable Land Information Management Courses, departmental management opted to pilot an in-house program to meet immediate needs.

Following evaluation of the first yearly program, a second was planned and commenced in May 1991.

This paper discusses the objectives of the program, the development of the syllabus, the selection of trainees, the creation of LIM career structure, the evaluation processes and future directions.

PILOTING AN IN-HOUSE TRAINING PROGRAM IN LAND INFORMATION MANAGEMENT

A Case Study - South Australian Department of Lands

INTRODUCTION

- The role of the Department of Lands is changing to meet the needs of an expanding market for land information services. Our continued existence will depend, not on our traditional services of surveying, mapping, land titling, valuation and public land management, but on the utilisation of our land data asset.

- Our major land information systems include the Land Ownership and Tenure System (LOTS), Digital Cadastral Data Base (DCDB), Automated Registration, Indexing and Enquiry System (ARIES), Torrens Automated Title System (TATS), Computer Assisted Valuation (CAV). Current initiatives include development of a Co-ordinated Cadastre, and Topographic Information System (TOPIS).

- The Department of Lands mission statement states (in part):-

  > "the Department of Lands exists to improve the social, environmental and economic well being of South Australia by
  >
  > * Collecting and maintaining land information for the benefit of our clients
  >
  > * Providing a secure land tenure system
  >
  > * Effectively managing Government land and property assets for the benefit of all South Australians."

- For the next three years every aspect of our operation will be assessed in relation to its relevance to our key directions which are:

  * Optimising Client Satisfaction

  * Enabling our people to achieve their best

  * Commercialising our performance

- In order to achieve our mission, we need people who are equipped to relate these key directions to our principal business of managing our land data asset. In short, we need Land Information Managers. (LIMS)

- Investigations and discussions with local tertiary education authorities revealed that current courses would not meet our needs. Whilst receptive to the introduction of suitable curricula, the lead time was too long to meet our timescale and they were at the time, preoccupied with amalgamation proposals. Accordingly, we decided as an interim measure to develop an in-house training program.

- This paper discusses the objectives of the program, the development of the syllabus, the selection of trainees, the creation of a LIM Career Structure, the evaluation process and future directions.

PROGRAM OBJECTIVES

- As well as developing local land information products and services, the department has been involved in overseas and national LIS/GIS consultancies. With a more commercial approach being adopted, these markets are expanding and it is necessary to provide opportunities for a greater number of employees to gain the required knowledge, skills and practical experience.

- A program to facilitate multi-skilling of employees from such diverse backgrounds as surveying, cartography, valuation and land registration was envisaged, so that future project managers would take a more corporate approach to development of land information services.

- The aim of the program is to equip selected employees with potential to undertake land information management projects, including the opportunity to participate in overseas consultancies once sufficient expertise has been gained.

- There was an expectation that successful completion of the program would be the start of a long-term career change from the trainees' professional disciplines to becoming generalist Land Information Managers. However provision exists for trainees to return to their former disciplines or seek alternative career paths where their participation in the program will have enhanced their prospects.

DEVELOPMENT OF THE SYLLABUS

- Having decided our objectives and the rationale for the program, the next step was to clarify the role of a Land Information Manager and to decide on the body of knowledge, skills, and experience needed to satisfy the requirements of the job.

- Considerable research was undertaken involving examination of courses within the appropriate academic disciplines conducted by local educational authorities. Information was also gathered on interstate and overseas courses, and contact made with any useful source. In particular, advice was sought from people both within and external to the department who had had relevant experience in roles similar to that of a Land Information Manager.

- As a result, a draft syllabus was built and a structure developed involving a modular approach to grouping of related topics into a logical sequence. Broadly it was agreed to cover the main disciplines of surveying, mapping, land registration and valuation, together with modules on public land management, LIS/GIS concepts, data administration, information technology, systems development, commercialisation and general management topics.

- Persons with the required expertise in each topic were identified and a series of planning seminars was held, resulting in designated presenters preparing outlines of their topics on an agreed proforma. From this information and subsequent iterative processes a co-ordinated syllabus evolved, including a timetable for the program.

- In general the training program provided for group learning activities intermixed with practical project work experience scheduled over a period of twelve months. Presentations included lectures, discussions, workshops, demonstrations, case studies, on-side visits and practical hands-on experiences.

- An outline of the original syllabus is shown as an attachment to this paper.

SELECTION OF TRAINEES

- It was decided that the selection of trainees should be based on merit and that a call for registrations of interest be made amongst existing departmental employees.

- Having regard to the requirements of the role of a Land Information Manager, the following broad selection criteria was identified:

    - Communication skills
    - Problem solving attributes
    - Interpersonal abilities
    - Information technology appreciation
    - Marketing awareness
    - Financial management knowledge

- In general, our aim was to recruit people with the potential to gain an intimate knowledge of land information systems (from data collection through to meeting the information needs of end users) <u>and</u> to acquire skills in data administration (involving protection of corporate data and ensuring its ongoing integrity). Over 40 employees responded.

- A selection panel conducted intensive interviews for 12 high priority registrants and followed these up with work reports from candidates' managers. Registrants were required to give a brief presentation to the panel on a topic of their choice related to Land Information Management. They were also required to show examples of their report writing abilities. A final list of 6 employees were recommended for approval by departmental management. This was deemed an appropriate number having regard to the administrative and financial climate and overall departmental priorities.

These were joined by 4 employees of other state and local government agencies and a post-graduate student from overseas. The quality of registrant was such that not all of the employees deemed suitable were able to be selected for the first program. By consent, their names are maintained in a register for future programs.

CREATION OF CAREER STRUCTURE

- Development of a LIM career structure has proved difficult, mainly because the South Australian Public Service is currently going through a major award restructuring process. We are having to wait until the new service-wide structures and classification criteria are determined and conversion completed before being able to submit a proposal for approval.

- Nevertheless considerable work has been done in identifying the role of a LIM within an organisational context. At this stage we have identified 3 levels of responsibility which roughly reflect the roles of a new graduate, an experienced operative, and a senior consultant.

- As an example, the following describes the role of the experienced operative.

1. Generally, acting under limited guidance, undertake the:

    1.1 development of major land related systems that conform with corporate policies.

    1.2 promotion of a corporate approach to systems development and operation.

    1.3 development and implementation of the department's LIS strategic plans.

    Also, Undertake or supervise others involved in:

    1.4 development of minor land related systems that conform with corporate policies.

2. Under limited guidance undertake projects relating to:

    2.1 establishing, monitoring and modifying land information policies, procedures, and standards for data gathering and maintenance.

    2.2 defining and documenting corporate land data according to accepted standards.

    2.3 Conducting post implementation reviews of land related systems to ensure conformity with agreed specifications.

3. Generally, contribute to the:

    3.1 promotion of the utility of the corporate land data base.

3.2 development of land data products and services

and:

3.3 provide advice on the effective utilisation of corporate land data

and assist in the:

3.4 conduct of Land Information Management Consultancies.

. It is envisaged that the new LIM career structure will be:

- attractive to employees from existing professional disciplines such as Surveying, valuation, information technology etc.

- flexible to allow for promotion within the structure and to provide for enhanced career prospects in other professional groups (eg. return to a former discipline, general management etc.)

- able to facilitate appointment at various levels to cater for differences in existing salaries of new entrants.

- capable of further development to recognise formal tertiary qualifications in the longer term.

EVALUATION PROCESSES

. Because the training program was breaking new ground it was important to evaluate its worth before deciding on its future. If repeated, it was necessary to learn what changes should be made to improve its effectiveness. An evaluation strategy was developed which involved feedback from participants, presenters and program coordinators.

. The participants, individually and as a group, provided regular feedback both during and after completion of their formal training. Topic presenters were asked to give feedback via questionnaires and the results were discussed at an evaluation workshop conducted after completion of the group activities.

. In summary, respondents identified that:

- The best things about the program were

  * the high quality of curriculum material and program administration

  * Meeting new people and developing an enlarged network of contacts

  * Appreciation of the wider LIS environment

- The worst things about the program were

  * Too much information in short time span

  * Some topics too detailed or theoretical

* Early project work required expertise not imparted until later

. As a result, the priorities for program improvement focussed on the need to:

* Introduce more reinforcement activities such as tutorials etc. between topics

* Re schedule some topics for a more logical flow of information

* Negotiate with presenters to improve the depth, breadth or practicability of their topic material.

* Restructure the program into a single block (semester) of group learning activities which would precede the allocation of practical project work.

* Extend exposure to external LIS agencies such as public utilities and local government.

. The department's executive were encouraged by the success of the first program and approved development of a second program which would incorporate the improvements suggested. An evaluation process involving more frequent and timely feedback from participants has been set in place for the repeat program, so that we can be more responsive to change.

FUTURE DIRECTIONS

. In the long term, our preference is to recruit LIMS with an appropriate degree in Land Information Management from a recognised tertiary education authority. Internal training would then focus on induction and professional standards. Until then, negotiations will continue with a view to introducing short courses, say at post-graduate level, possibly leading to the development of an undergraduate program which would involve a multi-disciplinary approach.

. Meanwhile, for as long as there remains an unsatisfied need for persons with skills in land information management, the department will continue to review its staffing options. If necessary, the in-house training program approach will be maintained and the present syllabus refined to meet contemporary needs. Negotiations with tertiary education authorities will accelerate as a clearer picture emerges as to the role of a land information manager both within the public sector and the wider LIS/GIS industry.

ATTACHMENT

SOUTH AUSTRALIAN DEPARTMENT OF LANDS

Original Land Information Management Training Syllabus

MODULE		TOPIC	
1.	Introduction	1.	Preview of the program
		2.	SADOL - Past, Present & Future
		3.	Need for effective Land Information Management
2.	Historical Development of the State	1.	Colonization and settlement
		2.	Survey and mapping
		3.	Land registration
		4.	Cadastral concepts
3.	Surveying	1.	Geodetic Network
		2.	Geodetic Instrumentation
		3.	Map projection and coordinate systems
		4.	Cadastral surveys
4.	Mapping	1.	History and overview of mapping
		2.	Map types and Techniques
		3.	Introductory Photogrammetry
		4.	Details of Map Production
		5.	Digital mapping
		6.	Remote Sensing
5.	Land Registration	1.	Legal framework
		2.	Land registration
		3.	Principles of Real Property Act
		4.	Easements generally
		5.	Conveyancing and registration process
		6.	Automated systems (LOTS, ARIES, TATS)

6.	Land Division	1.	Planning process
		2.	Surveying
		3.	Issue of Separate Titles
		4.	Mapping and DCDB
7.	Land Valuation	1.	Valuation functions and principles
		2.	The fiscal cadastre
		3.	Valuation techniques
		4.	Automated valuation systems
8.	Public Land Management	1.	Overview of Public land
		2.	Land Assessment & Planning
		3.	Property Management/Administration
		4.	Automated systems
9.	a. LIS concepts and Evolution	1.	Philosophy
		2.	International (other Countries)
		3.	Australia (other States)
		4.	South Australia
		5.	Future Directions
	b. LIS Applications	1.	Environmental
		2.	Facilities Management
		3.	Local Government
		4.	Mapping LIS integration
10.	Data Administration	1.	Philosophy & Issues etc.
		2.	Data admin. tools (analysis/modelling)
		3.	Linkages & parcel identification
		4.	Technical integration
		5.	Data Marketability
11.	Information Technology	1.	EDP appreciation
		2.	Advanced Information Technology

12.	Systems Development	1.	Analysis and design
		2.	Systems life cycle
		3.	Cost/benefit or business case
		4.	Report writing and presentation
		5.	Project management
13.	Commercialisation	1.	The business plan
		2.	Marketing approach and opportunities
		3.	International Marketing
		4.	Public sector financial management
14.	General Management	1.	In Search of Excellence
		2.	Time Management
		3.	Communication/Negotiation Skills
		4.	Effective Leadership

15. Supplementary Topics - to be advised

16. LIS Projects and work placements (To be advised by Directors)

17.	Evaluation	1.	Program review - debriefing of Participants, Presenters and Managers
		2.	Negotiate future placement of Participants
		3.	Proposal for improvements/future programs
		4.	CAE developments
		5.	Post implementation review strategy

QUALITY ISSUES
in
LAND INFORMATION MANAGEMENT

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ABSTRACT

This paper gives a broad overview of the quality issues that occur in operational Land and Geographic Information Systems (LIS/GIS). Quality is very difficult to define, as it ranges through intangible customer perceptions to rigorous measurements of positional accuracy. The need for measurement and documentation of quality is in turn driven by the corporate needs and business focus of any organisation. These factors will result in documentation being quite complex and difficult to prescribe. The data capture process of the Water Board's Integrated Facilities Information System is used to illustrate many of the quality processes that impinge on GIS operations. Finally, the quality section of the proposed Spatial Data Transfer Standard is briefly described and comments are made on the use of this standard for documenting quality.

INTRODUCTION

It is well recognised that in our society there is a major push for organisations to be more efficient and commercially competitive. Business success is increasingly being determined by market forces. In this situation, there is a requirement for products to satisfy the quality expectations of the market place. With the reality of commonly available digital spatial information now upon us, the land and geographic information industry must deal with the quality issues associated with spatial information.

The quality of spatial information will depend on the quality processes within organisations. These processes will be driven by the business activities of the organisation and will be affected by a host of organisational factors; people skills, technology, industrial relations and organisational practices. However, in order to satisfy corporate and market requirements, spatial information producers must implement quality measurement processes into their operational activities, while spatial information customers must determine what their true quality requirements are.

This paper deals with the quality issues in Land Information Management by attempting to identify a few concepts of what "quality" is and is not. Quality can be associated with many aspects of spatial data including terminology, lineage, positional accuracy, attribute accuracy, logical consistency and completeness. However, there are also intangible aspects like customer expectations and confidence, which are very difficult to quantify. The driving forces of quality are described in terms of the corporate requirements of the information producers. These business requirements will drive the types of spatial information that is stored, drive the positional accuracy that is maintained and drive the data maintenance processes. The Water Board's Integrated Facilities Information System (IFIS) is used to illustrate these processes.

Finally the complex process of documenting quality is discussed in the context of the proposed Australian Spatial Data Transfer Standard. This standard requires quality documentation to be provided with spatial data before it conforms to the standard. The components of quality, as prescribed, provide a broad and complete context for describing spatial quality. Such measurement and documentation will require a reasonable amount of resources to be assigned to the quality assessment process and must be justified in terms of an organisation's business requirements. However, it is not unreasonable to assume that eventually such documentation will be a necessity for the continuing maintenance of information systems and must be considered as an integral part of Land Information Management.

CONCEPTS of DATA QUALITY

The early development stages of establishing an operational Geographical Information System (GIS) usually focuses on data capture procedures. The procedures are often streamlined, where data capture is being accelerated at the expense of "quality" considerations. Quality in the early stages of data capture can be seen as a constraint, either in relation to slowing down the rate of data input, or used to maintain past manual work practices. Either way, experience has shown that quality issues are addressed again at a later stage of the data capture programme, usually when the data starts to be used.

The operational development of a GIS can be described in four data processes;

* input
* maintenance
* quality improvement
* analysis

These processes may be seen as distinct, but experience has shown that all processes co-exist. Data quality should therefore be managed in relation to all these processes.

As mentioned, the quality of the data will be emphasised during the final stages of data capture. The use of the data for analysis will only be undertaken when an acceptable confidence in the "quality" of the data has been achieved.

The increasing use of geographical information is being accompanied by an emphasis on the quality of the information (see Veregin, 1989, Goodchild & Gopal,1989). There is a tendency for this emphasis to focus on the positional or geographical "certainty" of data with an assumption that it applies to all spatial data regardless of input techniques, data source, operator skill or system manipulations. High quality is therefore often assumed to be synonymous with high positional accuracy, whereas quality in reality has other components as well. Defining quality is a difficult task, because the concept of quality ranges through intangible customer perceptions to rigorous statistical measurements of positional accuracy.

Quality measurement generally in the past has made the following erroneous assumptions;

(i) QUALITY MEANS GOODNESS
(ii) QUALITY IS INTANGIBLE, NOT MEASURABLE
(iii) QUALITY COSTS
(iv) PEOPLE CAUSE ALL QUALITY PROBLEMS

There has been much debate about the quality of information without understanding the nature of different business driving forces. It can be shown that data quality will depend on the use of the data in relation to the business need. Data quality should be seen as a conformance to a set of business requirements and non-conformance should be seen as a variation and not a measure of relative "goodness".

Quality of information as a product or service is measurable in terms of doing things wrong, the "real" cost involves full rectification, ranging from data amendment to rebuilding customer confidence. It can be shown that in these terms quality does not cost. Unfortunately, many organisations have lost sight of these principles, usually for reasons of accelerating the data input programme. No system is perfect, however, when problems occur it is usual to assume that people are the cause and often the system is examined as the last step.

In surveying circles, quality has generally been associated with spatial or positional accuracy. However, quality is an outcome associated with meeting business needs. Positional accuracy is only one facet of quality measurement. The measurement and documentation of positional accuracy will be an important component of quality documentation. However, the notion of quality must also include attribute accuracy, data topology, information sources, data input processes, completeness and also customer confidence.

THE DRIVING FORCES of QUALITY

BUSINESS REQUIREMENTS

The operational activities of many agencies providing geographical information services are increasingly being driven by customer demands and commercial practices. Customer priorities may either be determined by internal operational needs, or, by satisfying an external market demand. This change of focus to being more customer oriented has also emphasised customer confidence in the use of this service or product. Customer confidence can be seen to be directly related to the quality issues. As soon as digital data is marketed and used, there will be a requirement for standards to be adhered to. Customers want to know "what" they are buying and how "good" the service or product is.

As mentioned, the business activities of an organisation will be the main driving force for data quality. For example, within the Water Board, business activities may be categorised in relation to; customer services, asset management and environmental management. Each business activity produces a set of data and accuracy requirements which are different and are continually transformed to meet new functionality, increased data resolution or granularity, value added processes, data consistency and cross functional relationships (see Table 1; Ryan & Masters, 1991).

Driving forces:		Data requirements:
customer services	--->	geographical position data attributes
asset management	--->	geographical position network continuity data attributes
environmental mgt	--->	geographical position data attributes data correlation

TABLE 1 CORE BUSINESS ACTIVITIES and DATA REQUIREMENTS within the WATERBOARD

From experience, it can be shown that the business driving forces have different spatial accuracy requirements. If the business needs are greater than the information system can deliver, then a genuine attempt must be made to introduce justifiable operational changes, or ensure that the customer understands the spatial accuracy limitations. It is unacceptable to deliver information knowing that it will not satisfy customer requirements. The eventual customer back-lash will have long term adverse effects in relation to customer confidence and system credibility.

The theoretical assessment of positional accuracy, as a measure of quality, has tended to avoid understanding the driving business forces that determine positional accuracies. The cost of increasing positional accuracy without being supported by a sound business case would be unacceptable to any corporation. In this case, the assessment of positional accuracy must be related to customer expectations. It is also true that if positional accuracy was varied to a lesser standard below customer expectations, the rectification cost has been estimated to be of the order of 10 times the original data capture cost. However the "real" cost is inestimable in terms of customer confidence and subsequent use of the system.

QUALITY MANAGEMENT

SMARTER PROCESSES

Quality management can be seen as a systematic way of guaranteeing that organised activities involving information, people, technology, business activities happen the way they are planned.

Information technology is being progressively developed in many organisations. However, individual information systems within organisations are often fragmented and disparate. The full potential benefits of these information systems arise from integrating individual systems to form corporate information systems. Information Technology planning is therefore becoming part of the integrated corporate, business and financial planning cycle. The alignment of business and information technology planning will ensure that operational priorities will be addressed. As such, it is critical that land and geographical information systems are integrated into the operational systems and address corporate and business objectives.

Also, far greater understanding is required in the Information Technology Industry by management, workforce and trade unions about the integral relationship between technology, people skills, organisational practices and industrial relations. Immediate steps are needed for this integration or the present fragmented approach will continue. Too often the focus has been on the technology at the expense of the people, organisational and business issues. All these factors will affect the quality of information produced by an organisation. The development of a state wide land information system will obviously be affected by the same issues, but on a far wider scale.

The integration of systems has a direct relationship with data management and the accuracy of spatial information. With moves towards commercialisation and customer focus, data quality as a measure of "goodness" is a critical factor in relation to customer confidence in using information products or services. It is critical that the shape of the organisation, people's technical skills, level of technology and business priorities are all addressed in terms of data quality.

SPATIAL DATA BASES

The Water Board's IFIS data base is a good example to illustrate the types of quality issues that can arise. Figure 1 shows the processes used for cadastral data capture in the WaterBoard's IFIS data base. The basic sub-processes are:

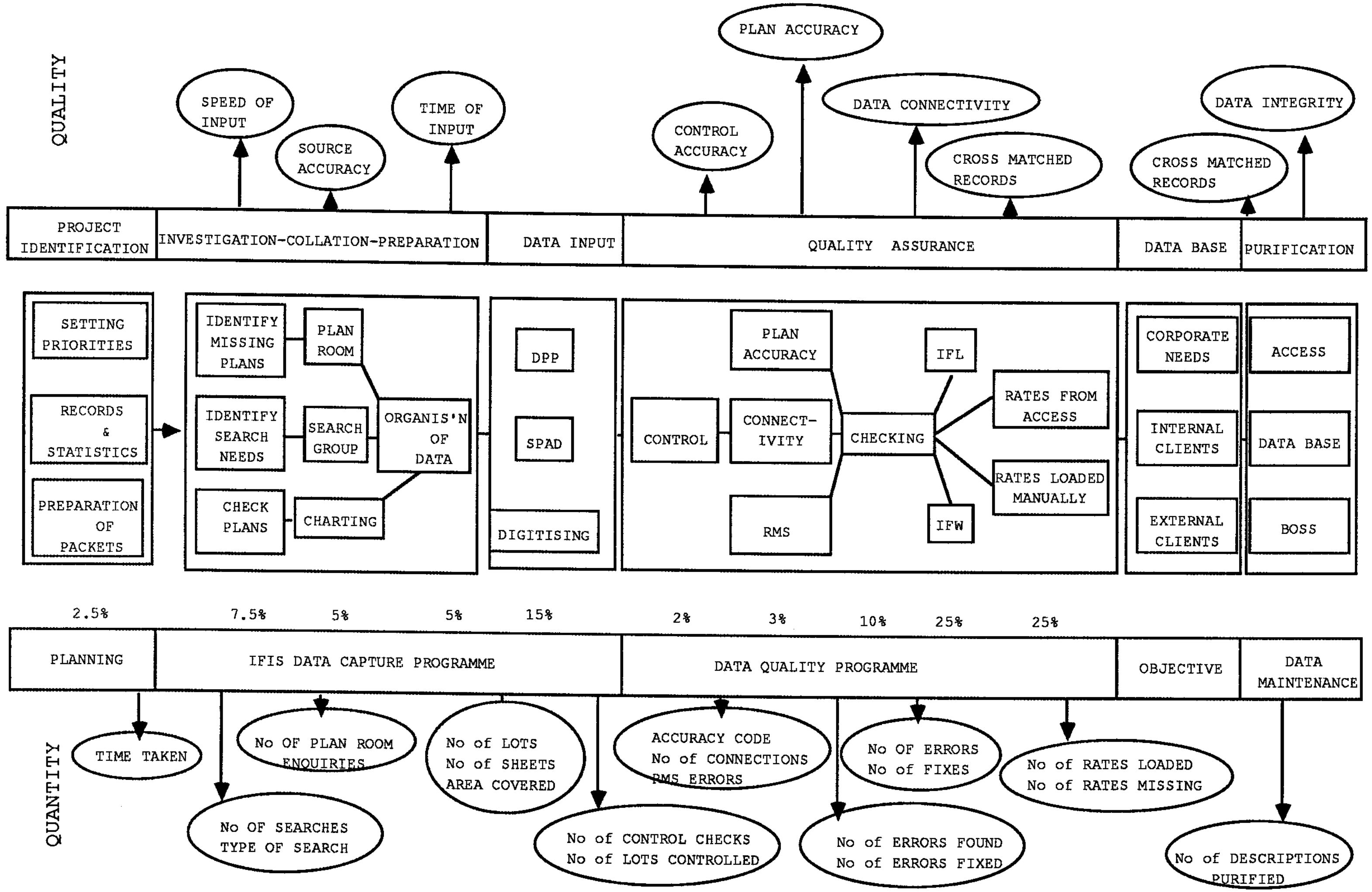

Figure 1: IFIS Data Capture Processes

* project identification
* investigation, collation and preparation of existing documents
* data input
* quality assurance
* data base management
* data base purification

The data maintenance process is very similar to the data capture processes, except that less time is spent investigating and collating the initial documents.

It has been noticeable, that as the IFIS data base has evolved, the percentage of time spent on quality control procedures has increased, whereas the time spent proportionally on data input has decreased. Early in the life cycle of the project, the percentage of time spent on data input was driven by the need to have the data base up and running. In the early stages, time spent on quality processes amounted to about 50% of data input activities, whereas in Figure 1, the quality processes have increased to 65% of the time taken for data capture. In the same way, performance indicators only reflected the quantitative aspects of data capture, such as how many plans were digitised, what regions were captured, and the number of map sheets completed. Performance measurement is still more quantitative than qualitative. However, as the database has neared completion, the need for more quality assessment has been realised and steps are being taken to further develop quality measures for the system. As an observation it would seem that quality issues are only emphasised when the information systems become operational.

At the investigation stage, as shown in Figure 1, quality assurance involves assessing the available source documents, determining the most suitable input process, assessing the availability of survey control data and the quality of previously digitised line work. The positional accuracy, and hence quality of the final database to a large extent will depend on the quality of the original source material.

Many of the quality assurance checks are made during and after the data digitising stage. These quality assurance processes involve checking the source plan accuracy, checking the registration of control data during map digitisation, and checking that the correct topological relationships have been entered. The IFL (InterFace Library) and IFW (InterFace Workspace) processes in Figure 1 also check the spatial data for possible internal inconsistencies. Finally the Lot and Deposited Plan identifiers are checked during the matching process with the property numbers in the ACCESS (Automated Corporate and Customer Enquiry Support System) database. Typically the automatic matching of these databases is successful at the 60% to 70% level depending on the geographical area. These quality assurance processes could be considered minimal, but still consume 65% of the data capture process. The final purification process is a manual process used to match up the graphic data with the property numbers in the ACCESS database. The time for this process is additional to the data capture process. Quality assurance processes for IFIS also include feedback from customers, who can enter a log of observed errors into the system. The log is used later by database maintenance staff to correct the data.

QUALITY DOCUMENTATION

In Geographical Information System literature, many thoughts have been expressed on data quality over the years. Chrisman (1983) makes some comments which are relevant to this work. He states that "quality information provides the basis to assess the fitness of the spatial data to a given purpose, and also provides the handle for long term maintenance".

The deliberations of the working group on data quality for the United States Spatial Data Transfer standard resulted in the opinion being expressed that: "Standard Quality information in a database should communicate information from the producer to the user so that the user can make an informed judgement on the fitness of the data for a particular use" (Chrisman, 1983).

Quality is not just about positional accuracy but embodies a host of perceptions and performance criteria. Measures of quality can therefore range from being very subjective to being extremely rigorous. Documenting quality is therefore a difficult process and covers many aspects apart from assessing positional accuracy. The proposed United States Spatial Transfer Standard provides useful guidelines for documenting the quality of spatial data.

THE SPATIAL DATA TRANSFER STANDARD

The proposed United States Spatial Data Transfer Standard is proposed for adoption in modified form as an Australian Standard (ACSM,1988; USGS, 1990; Clarke, 1990). This standard contains a section, which is designed to facilitate the documentation of quality information and to transfer this information with the spatial data. Indeed, data must have a "quality statement" of some sort to comply with the standard. There are many benefits in adopting this standard, especially in the area of data quality.

Quality, according to the standard, has a very broad definition. The actual measurement of quality is basically left to the producer to determine. However, the concept of the standard is "truth in labelling" rather than prescribing any specific quality measurements, although some specific types of quality documentation are suggested. On the whole the quality section of the standard gives a good general guideline to follow, but the specific application of the guidelines are left to the data producer's interpretation.The proposed spatial data transfer standard suggests documenting quality under five headings :

Lineage

A lineage report includes descriptions of the source material and all the processes involved in producing digital spatial data.

Positional Accuracy

Positional Accuracy defines the closeness of the locational information to the true position. The positional accuracy can be measured using four methods:

- A deductive estimate based on knowledge of the production processes.
- Internal evidence based on measurements within a database such as residuals from adjustments.
- Comparison to source documents, possibly using graphical inspection.
- Comparison to independent source data of higher accuracy.

Attribute Accuracy

Attribute accuracy defines the closeness of any attribute data to their true values. The measurement of attribute accuracy will very much depend on the nature of the data; its continuity, its categorical attributes. The accuracy of attributes can be measured using three methods:

- A deductive estimate based on knowledge of the data capture processes.
- Tests based on independent samples to show the misclassification of the data.
- Tests based on polygon overlay.

Logical Consistency

The fidelity of the relationships encoded in the data structures are reported. Specific topological relationships between graphic objects can be reported, as well as the general consistency of the graphic data; missing features, extraneous features, overshoots, undershoots.

Completeness

The selection criteria, mapping rules and definitions used are reported.

Terminology

One area where the standard will help is in the definition of spatial terminology. The standard has a very comprehensive list of definitions to describe spatial data. These definitions may need some modification for the Australian community and will probably also require some additions as the technology and spatial theory develops.

The adoption by the spatial data community of standard terminology is important as it will help ensure that producers and consumers of spatial data are talking the same language. It is fairly easy to surmise that many complaints about poor quality data are actually derived from the fact that the purchaser did not understand the type of spatial data they were acquiring. This fact may not be their fault, because without standard terminology and documentation procedures, the spatial data producers cannot inform potential customers what their data actually is. In this case, it is therefore possible, to trace complaints about lack of good data quality back to an inherently more fundamental problem than just poor positional accuracy. One person's line may not be another person's arc. Digital spatial data is fundamentally a different and more complex product to deal with than the paper map.

Documenting Lineage Information

Many government operated land information systems, are not static in space or time. The historical nature of the database and the evolutionary processes imply that updates are sporadic and spatially scattered. Lineage and accuracy information on the database is therefore fragmented and unfortunately often not well documented. Much of the information on source data may only be in the memory of the operators. If key operators are no longer available after organisational changes, problems of documenting lineage information are compounded. This type of information must be documented, not only for providing future quality information, but also maintaining vital operational information.

For organisations that have produced spatial data for their own organisational purposes documenting lineage information may be difficult. For example, conventional mapping standards may have not been adhered to. Also plotting standards change, geodetic datums change, source media change. Even if the lineage data can be identified, it may be of little benefit, because the related information cannot be found, and if it can, then it may be very difficult, if not impossible, to interpret.

In the same way, the digitisation processes evolve. The methods for registering maps to the control coordinate systems can change with time. At one stage, maps may be registered using plotted coordinate grids. At other stages, say during maintenance procedures, data may be registered to surveyed control points. There must be a significant difference in accuracy resulting from these procedures.

Also for an organisation with a reasonably long history, the base geodetic coordinate systems change. Geodetic networks periodically have major upgrades to improve their overall accuracy and coverage. These changes can be significant and are inherent to the source data and may or may not be documented. Unfortunately, these changes in coordinate system will often be fragmented and unquantifiable using simple mathematical formulae. For organisations with a long history of mapping therefore, the transformation processes required to convert old maps to any current projection and datum will probably be very complex, and will be based on empirical methods, rather than having a firm theoretical basis. Empirical procedures may be fine in themselves for specific applications, though their inherent accuracy should be carefully assessed. However, there is also a danger that the transformation procedures may be adopted for inappropriate applications and for general usage by inexperienced staff at a later date.

As data is being updated or maintained, the new data is usually more accurate than existing data. From experience, new data can cause significant positional changes in the older data in accommodating this change in accuracy. As yet, there are no rigorous system procedures that satisfy all update situations. The reasons for the differences may be due to previously mentioned factors amongst others. The complexity and heteorogeneity of the differences in the source maps and plans will probably mean that accuracy information must be stored as an attribute in any information system.

Documenting Positional Accuracy

The standard map accuracy confidence statement, such as "90% of well defined points will be within 0.8 mm of their true position", will probably always be a well used positional accuracy statement. Such statements do enable the consumer to make a subjective value judgement on the accuracy of data and it is probably reasonable to assume that much data will be purchased on such statements, especially when there is limited amounts of data available. However, these statements are difficult to actually interpret in terms of multi-layered information systems and GIS functionality (see Masters, 1991). If "valid" accuracy statements are to be obtained for any type of GIS function, more carefully thought out accuracy assessments and documentation will be required.

The term positional accuracy, at face value, seems straight forward enough. However, what does positional accuracy mean in the context of spatial information systems? The proposed standard uses "positional accuracy" as a major part of the quality report. However positional accuracy seems to imply a very narrow concept of the accuracy of the coordinates on the map compared to the base geodetic datum. This concept of positional accuracy is derived from existing map accuracy assessment procedures and is very much "paper map" oriented. In the context of digital map data, Spatial Information Systems and sophisticated analysis procedures, the concept of accuracy must be re-evaluated. The same conclusion can be reached by examining the types of accuracy assessment procedures that have been investigated in the literature (Veregin, 1989, Goodchild & Gopal, 1989).

The documentation of positional accuracy must be relevant to the types of analyses to be done and should also be understandable. Unfortunately, these two requirements may conflict unless the customers are expert statisticians. All-encompassing accuracy statements like: "this data is accurate to one metre", only give a "feeling" for accuracy and are of little use if the accuracy of results from sophisticated GIS analyses are required. One way to overcome the conflict is to have different levels of documentation. The first level will give a simple, easy-to-understand and comprehensive statement of database accuracy. Other levels will be more detailed and statistically correct, so that error theory can be used to determine the accuracy of GIS analyses and eventually the validity of decisions made from the analyses. Eventually, such documentation could be transparent to the customers, while it is used to provide accurate error estimates of GIS analysis. The detailed levels of accuracy documentation must of course be justified in terms of the producer's business requirements.

CONCLUSION

The determination of positional accuracy is but one component of quality. Other aspects like attribute integrity and graphical completeness are just as important. Any measurement of positional accuracy must be considered in the context of complete quality documentation. Also, the cost of producing appropriate quality statements may not be justifiable in terms of cost for any specific organisation. Unfortunately, many data producers are marketing spatial data as a by-product of their own organisational needs. In this situation, there will be little requirement for sophisticated documentation of quality, except for the producer's own requirements. This situation should change with increasing use of digital spatial information.

The quality section of the spatial data transfer standard is a useful starting point for quality documentation. However, standard documentation will only really be developed when data producers actually start providing quality measurements with their spatial data. In this case, the standard does provide a useful framework for documenting quality.

As customer demands for quality increase, corresponding changes will need to be made to information systems. The changes must address all operational aspects which include information, organisational, technological and people issues, all components of the "whole" system. Customer satisfaction makes no distinction between the performance of the individual components. It is concerned with the final outcome in fulfilling an expectation. If customer expectations for say positional accuracy are greater than a system can provide, then a genuine attempt must be made to introduce justifiable operational changes, or ensure that the customer understands the positional accuracy limitations. These requirements will provide an immense challenge to the producers of digital spatial information to measure and document quality. Dealing with "quality issues" must therefore be an important component of Land Information Management.

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DEVELOPMENT AND IMPLEMENTATION OF SPATIAL/ASPATIAL DATABASES AT THE NSW LAND TITLES OFFICE

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ABSTRACT

The Land Titles Office's reference map system when viewed through current technology has restrictions reflecting a system developed over time. These factors, coupled with all the recognised limitations of a paper based, manual reference map system, pointed to the need for an easy care solution capable of integration into today's environment. The development of the NSW Land Information System is the agent by which the transformation from a paper to a computer based map system with overlays and indexes will become a reality.

The successful development and implementation of a pilot computerised Cadastral Index (charting map system) containing two complete Local Government Areas is discussed. Expectations are that this will be the successor to the Office's current manual reference map system.

INTRODUCTION

To satisfy the twins 'public service' and 'office productivity', the Land Titles Office of New South Wales (LTO) has fought hard and tirelessly on all fronts using all available means. In more recent times it has enlisted that many headed dragon 'technology'.

In the 1960's, use of photographic reproduction to produce Certificates of Title coupled with the Plan and Dealing microfilm systems was introduced. Then, in the 1970's came the use of extensive computer listings (Land Indexes) and the initial development of a computer based title system. The 1980's brought the introduction of the Automated Land Titles System (ALTS) and initial development of the Business Operations System (BOS) to enable computer lodgment of land transactions (dealings) and their storage. Development of a Graphic Data Base (GDB) began as part of the state's initiative for a NSW Land Information System. LTO's movement into imaging technology for the migration of its deposited plan file from its aperture card system was also commenced.

Discussion on what the 1990's has already provided and will provide with its closure will be touched on later in this paper.

The essential elements of this paper are directed at one of the office's latest initiatives, the development and implementation of LTO's computerised Cadastral Index. In this, the first marriage of both the data sets (spatial/aspatial) and products (Genamap/Oracle) in a unix environment (HP-UX) under the LTO's model with consideration of the NSW LIS.

LAND TITLES OFFICE OF NEW SOUTH WALES

Objectives

The LTO currently operates on a standalone commercial basis and has done so since the middle of 1988.

The main operational objectives of the Office centre on land title registration, boundary definition and the provision of land information.

To achieve its objectives, development through the utilization of modern technology is seen as essential. Development funding is sourced from a proportion of the Office's revenue derived from its operations after the government's dividend and office expenses have been accounted for.

Structure and Development Source

The operational divisions of the Office are supported by administrative elements, as well as staff surveyors, a legal division and a computer services group.

The development of LTO's computerised Cadastral Index has been carried out under the auspices of the Land Information Services Division, by Charting Branch's Computer Development Section staffed by survey drafting officers. The responsibilities of the branch are numerous but are primarily the maintenance and provision of charting maps (cadastral indexes) pointing to survey and titling detail. These manual or paper based cadastral indexes provide not only graphical representation of the legal parcel fabric of NSW but also point to and often graphically display the extent of historical realities i.e. prior subdivisions, grant details, past government resumption action etc. It is the most complete, current and accurate paper based cadastral index in New South Wales.

THE COMPUTERISED CADASTRAL INDEX

Background

As part of the development of a computer based Land Information System (LIS), The State Land Information Council Directorate (SLICD) invited tenders for the development of a computer based mapping system in the mid 1980's.

Genasys II Pty Ltd was awarded the tender. Genasys has sophisticated software for the management, manipulation and integration of maps on computer ("Genamap"). As part of that successful tender, the computer platform of choice was Hewlett-Packard with its unix flavoured operating system "HP-UX". These two elements, "Genamap" and "HP-UX" were coupled with a Relational Database Management System (RDBMS) "Oracle".

Principle trustees involved in the State LIS took responsibilities largely in accord with their particular areas of operation. Particularly, the Lands Department through its Land Information Centre (LIC) is responsible for the supply of the base cadastral data, the 'Digital Cadastral Data Base' (DCDB) in a usable format and in a timely manner.The LTO, source of the data, validates the spatial relativity of the captured data and supplies the Lands Department (LIC) with newly registered plans for inclusion in the DCDB.

Why Computerise the paper Cadastral Index?

As a result of the very nature of development in NSW and the approach taken with survey practice in its earliest developments (surveys performed over a wide area and not necessarily co-ordinated) the display of this data on a continuous map base has been problematic. In modern times the move is towards a fully co-ordinated cadastre, but as said, historically the LTO has had to deal with charting systems of various formats and structures. From the pyramidal system with its layers of references maps to the Central Mapping Authority format with its single layer, all with their inherent problems. This is the environment in which LTO's paper cadastral indexes have grown to maturity and reliability.

The fact that it is a paper based system is a problem in itself;

* Data loss through paper damage
* Multiple users find difficulty accessing one copy
* Multiple copies create storage and maintenance problems

* The scale at which they were originally drawn is no longer appropriate
* Replacement can bring transcription errors
* The display of certain types of data is no longer appropriate
* There can be conflict between internal office use and public use
* Physical storage and display is often clumsy and difficult
* Tracking and control of usage often problematic

The means to a solution was provided through the use of a computer based Geographic Information System (GIS), namely "Genamap" and the timely introduction of the State (LIS).

The Model

The Model Itself

The Model consists of a series of spatial layers capable of overlay and spatial interrogation and relativity. Some layers will consist of area features (comprising lines and points and/or line features) and/or point features. A point feature is a point with definitive co-ordinates and tagged as is appropriate. The aspatial data is held in relational tables, either permanent or temporary by nature and independent or joined to other tables.

i) Cadastral Base Layer

The base cadastre is the DCDB supplied by the Lands Department through the State LIS. With updated data (newly registered plans etc) supplied by LTO for inclusion by the Lands Department. The DCDB is to be current and by definition is "the legal parcel fabric of the State". In the short term, LTO will maintain its own seamless base held in Geographic projection, awaiting availability of the seamless DCDB and an adequate, complementary text layer.

ii) Cadastral Base Text Layer

This layer is a necessary adjunct for the base layer because Genamap stores text in a separate layer and this is usually developed at input stage. This element has proved to be one of the most critical factors in our processes. It is seen as absolutely essential that if the cadastre is to be meaningful, the pin or tag attached to a polygon in the DCDB layer must be reflected in its text layer and displayed at output (for example if a parcel exists as a particular lot in a plan then it should read as such when displayed as the text layer). This layer will be referred to later whilst discussing the project and its implementation.

iii) Notations/Plans Index

This spatial layer is the LTO specific index layer. It provides the ability to spatially locate the references to all plans (both historical/current), the titling detail as well as lodged but unregistered plans. The spatial layer carries point features and references relational tables to access aspatial data. Data is inputted with consideration of the DCDB and its accompanying text layer with control by "Oracle". Building is by way of both manual input and automatic generation from current plan records.

It should be noted that this index contains, as already said, reference to all current plans as well as historical plans.

The spatial data within Genamap is held as point features with definitive co-ordinates carrying a unique number supplied and controlled by "Oracle". Within the relational tables there is a many to one relationship (multiple sets of co-ordinates can point to one record).

iv) Parcel Index

The parcel index provides a fast and efficient means of enquiring on the Cadastral Index and provides data at output. It contains:

a) A meaningful Genamap tag from the DCDB
e.g. G13/1/1/123
field G = Manually validated at LTO
field 13 = Not a special use parcel of land
field 1/1/123 = unique identifier (Lot 1 Section 1 Deposited Plan 123)

b) The Genamap tag into its component fields (as in a) for dissection by the enquiry engine, and for component update.

c) The appropriate Local Government Areas for each parcel.

v) The Crown Plan Table

A spatially related Oracle table used as part of the building block for data capture and for the provision of aspatial data based on a spatial enquiry. This data gives reference to a Lands Department plan where an administrative Deposited Plan number has been used.

In the provision of a unique identifier not all references to a LTO deposited plan number produces a plan (either of survey or compilation). Such is the case with Parish Portions that exist within a County map and Town Allotments within a Town Section. The specific Parish Map (of which the portion is a subset) has been given a unique identifier (DP number) as with a Town Map (of which the town allotment is a subset), has been given a unique identifier (DP number). To enable provision of a plan (either of survey or compilation) cross reference must be made through its unique identifier (lot, section, deposited plan number) to obtain reference to the Crown Plan number. (i.e. the plan of survey/compilation).

Use of Genamap/Oracle

Identified early in the development process was the need to incorporate not only spatial data but aspatial (textual) data as well. The principle of attributed polygons was one that was being considered by nearly all exponents in the industry and whilst it would need to be incorporated in our model to enable real time collection of historical detail (superseded plans as well as other titling data) other processes and attitudes would have to be adopted. The result was that in part, the model incorporated area features (polygons) with attributed data held in relational tables, controlled using "Oracle" and fed using "Genamap". As well, point features are also attributed in relational tables using the same control, "Oracle" and both area and point features are capable of output in both spatial/aspatial format through "Genamap" or aspatial through "Oracle".

Input is currently through imbedded SQL in 'C' programmes and developed formats. Spatial linkage is made through "Genamap" to be passed for inclusion in the various joined relational tables and is controlled by "Oracle"/"Genamap".

Output on enquiries are made through a Graphical User Interface (GUI) "Genius" (a Genasys II product) accessing the functionality of "Genamap", the power of the operating system "HP-UX" and control is provided by both "Genamap" and "Oracle". Spatial data exists under Genamap format and aspatial data in relational tables with Oracle management.

The Process

From determining User requirements through prototyping to the implementation of the Pilot.

Initial Development of User Requirements

The first step was to clearly identify our cadastral index users, these being;

i) The Office itself
ii) Surveyors
iii) Solicitors
iv) Conveyancing agents generally
v) Developers
vi) Any person interested in land titling data.

The specific needs of each grouping were determined and processed. It could be clearly seen, even at that early stage that both spatial and aspatial data were required with access needed to both our plan file (copies of all plans held in the Office) and our title system (ALTS). These requirements were determined by interview, poll and the assessment of our collated statistics. This was heavily documented and presented to our consultants for development of a prototype for review and dissection.

Prototype

Prototyping pointed to viability, with the elements to be noted being the pivotal points and obstacles. One major obstacle is the way that Genamap uses its text layer (whilst other layers are capable of enquiry the text layer is incapable of enquiry or interrelating to other layers).

It was also at this point that a practical approach had to be found to collect our historical data. If, as the State LIS model indicated, this data was to be attributed direct to the DCDB then the office would be looking at an almost impossible task. If the human resources were available, the skill level or rather experience to interpret our paper cadastral index (charting maps) takes some time to develop. It should be noted here that indeed, many a good living is made searching these records. The method adopted was quite straight forward. The absolute boundaries of the historical data would not be shown, but capture of a point feature attributed with the necessary fields to give it meaning, would.

This would solve the problem of a seemingly impossible capture programme and overcome the problems associated with a shifting (dynamic) base cadastre when the DCDB was upgraded. Over time the DCDB will be upgraded to reflect a co-ordinated cadastre, this should not be mistaken for update action which would reflect only a change in the subdivisional pattern.

Other elements that presented problems was capturing and outputting of current plan references. Reference to current plans was already held in the DCDB, therefore it was felt that an automated procedure must be provided. With performance or rather response time being of an absolutely critical nature at any public enquiry point, it could not be left at output time to break down the DCDB tags, remove duplicates, join with other tables of attribute data, check for precision and output the results. The creation of a further point feature was adopted for these current plans with the records being expanded to contain the appropriate attributal plan data i.e. type of plan survey/compilation, purpose of plan, currency etc.

When it came to an enquiry on our computerised Cadastral Index one of the conundrums faced was, defining a spatial area for output without dictating to the client what must be viewed. The process adopted is not seen as a 100% result, but rather one that will solve 98% of enquiries. The solution uses a sampling process based upon the point of enquiry and the area of the polygons in the proximity. It culls all polygons with areas above a certain size then from the remaining sample, culls the remaining largest and smallest polygons based on their areas, averaging the remainder and comparing the average area of the sample against a look up table, to determine output parameters.

Other smaller interesting elements were exposed during this phase, but are too numerous to elaborate on here, but that is not to say they were of less importance. This phase in hindsight, proved to be the most crucial and I would recommend that evaluation of any prototype should be detailed.

Detailed User Requirements and System Specifications

These took some 6 months to complete and resulted in a 170 page document titled accordingly and dated May 1990. It can be considered a most complete document and covers all aspects from software expectations to database design and the administrative controls required.

Data Capture

Data capture would also prove to be absolutely critical when it came to maintenance of the databases and on outputting the necessary spatial/aspatial data at enquiry time. Whilst the heavy use of coding made the input often appear cryptic, it reduced data entry, provided good administrative control and produced acceptable results. All expansion of coded values was done post input and the data base in fact contains the expanded prose to speed output and assist in its formatting, prior to output.

The Pilot Project

It was determined that this would encapsulate two local Government Areas, The Shire of Byron and The City of Lismore on the northern NSW coast, contain live data and be maintained as such. It would also provide focus for future development and develop skills commensurate with future needs and expectations.

Development of the software necessary for the pilot was made by the consultants Genasys II Pty Ltd and consisted of Genamap scripting, shell programming, C programming with imbedded Structured Query Language (SQL), Oracle SQL scripts and 'HP-UX' processing.

The pilot also incorporated all the elements that preceded it with consideration of where the office might progress in the future.

Considerations at Implementation

Output devices were seen as a principle consideration, but it is expected that greater deliberation will be made at the next phase of development. The use of laser printers was seen as a major positive when quality and speed of hardcopy was assessed. "HPGL" was the preferred method of graphic generation but the use of "postscript" will be considered with future developments. The display and access at enquiry time is currently through Hewlett Packard (HP) 9000series360 workstations with HP "X" terminals currently being assessed as a more cost effective device.

The use of "Oracle" from multiple machines requires the implementation of their networking product "SQL*Net" and this is in the process of being done.

The Product of the Cadastral Index

On enquiry, output will comprise the following principle elements.

On Screen

Visual display of maps and related notation information with the ability to zoom in/out by 20% to a maximum of 120% or a minimum of 80%. 100% being the displayed area at the point of entry. It should be noted that in this phase of development, entry will only be by Lot Section and Plan Number or a Strata Plan number. Future enhancements will broaden this point of entry to include street address etc.

Hardcopy Output

Prints of the screen displays, as well as lists of plans within the area of interest, will be available. The plan lists will comprise 3 separate lists, one for each of Strata Plans, Deposited Plans and Crown Plans. These will not be bland lists of plan numbers but will include such meaningful elements as plan type (survey/compilation), plan currency and plan purpose. These plan lists will conform to the area of interest and be applicable to the display, be it a 80%, 100% or 120% output. An important point to note, is that they are intended as picking lists and they, in conjunction with the other hardcopy output, provide all the information necessary to determine what plan copies could be required. These lists also provide an order form for our plan copy service. Please note, although the enquiry mode is very user friendly, an operator will be supplied in the public area at its introduction.

THE FUTURE OF THE PILOT PROJECT

It is anticipated that by the time this paper is published testing will be all but complete and installation into other areas of the Office will be taking place to allow system evaluation in a real time environment.

Initially, terminals will be located in Plan Investigation Branch and the Plan Room on the 2nd Floor of our Office. Realistically it would be reasonable to expect remote access and phone enquiry with fax out results in the future.

Provision of the computerised Cadastral Index outside the pilot area will be dependent on various factors (including acceptance by this Office). The availability of a seamless base cadastre (DCDB) along with the provision of its complementary text layer (previously referred to) are seen as absolutely essential.

The absolute direction, post pilot will not be seen until dissection and evaluation has been completed.

Future Office Connectivity

It is seen that over time this index will be linked and indeed access ALTS and its complementary system, BOS (Business Operations System) as well as the plan file. The plan file is currently the subject of a project to convert across to optical disc, making copies of the plans available as images for both hardcopy and screen format.

CONCLUSION

The LTO has a solution for the input/output of spatial/aspatial data using "Genamap" and "Oracle" in a Unix environment "HP-UX". It provides an effective mode of enquiry with realtime output. Currently, we are carrying a live "Oracle" database with 44,000 records and a seamless spatial database with approximately 60,000 "current" parcels of land.

The experience and knowledge gained will assist all involved in the management and development of NSW's Land Information System.

As a final comment, don't underestimate the value of your prototype and what it might or might not be saying about your data management expectations.

Principal Consultants used:

Mr. Glen Birmingham
Mr. Lars Hansen

DATABASE MANAGEMENT - VISION FOR THE FUTURE

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ABSTRACT

A future view of database management technology is given from the land information management perspective. Research directions in database management technology are identified. These are related to future requirements in land information systems (LIS). Some research efforts being conducted in the LIS context are described.

INTRODUCTION

Land Information Systems (LIS) are concerned with one of the broadest information bases conceivable. These systems are concerned with the real world, not some abstract model of commerce such as that used to conceptualise a business database (although such databases are elements in an LIS). LIS will be used by the entire community. The main industry sectors and funtionaries which act as sources and users of land information are summarised below.

Conservation
- Heritage, Historical, Environment

Defence
Emergency Planning
- Floods, Fire, Accident,Earthquake

Environment Management
- Pollution Monitoring

Directory Services
Facilities Management
- Communications, Electricity, Gas, Water&Sewerage
- Roads, Railways, Airports

Land Management
- Registration
- Cadastral Management

Political and Administration
- Electoral

Population
- Statistics, Enquiry

Primary Industry
- Forestry, Agriculture, Exploration

Real Time Control
- Navigation, Traffic Control

Revenue
- Valuation, Land Rent, Rates, Taxation

Town Planning, Rural Planning
Transport
Zoning

The database needs of the Land Information System (LIS) community are concerned with a diverse range of entity, data and relationship types. Identification of this information provides the basis for examining database management. A summary of the main data types is given below.

2-Dimensional and 3-dimensional plans and models
- Infrastructure design and installation
- Boundaries
- Linearised routes and courses
- Terrain models

Images
- Georeferenced pixel based spectral images
- Theme classified georeferenced images
- Ortho-photographs
- Photographs
- Elevation models and perspective views
- 3D geophysical models
- (time sequences of the above)
- Scanned documents and plans

Grids
- Regular and irregular gridded survey data
- Time series data

Text
- Coded character free-form documents
- Coded character structured (formatted) data

Audio

The following is a broad catagorisation of the computer based applications which arise in an LIS.

Ad Hoc Enquiries
Analysis for Exploration or Conservation
Commercial and Administrative Transactions
Decision Support
Engineering Design and Maintenance
Planning
Research

While land information management is still grappling with the move of its geometric database from the hard copy media, advanced techniques for data generation and conversion are making spatial databases a reality. Many applications, which are part of daily life, involve several databases spanning separate organisations. The extent of these applications, and the complexity of entity and data types, have stretched mainstream database technology beyond its capability. Thus LIS are becoming a significant driving force for the technology.

In this context some of the important factors and trends in land information management are remote sensing becoming the dominant form of data generation, 3-dimensional models, commercial GIS systems moving away from proprietary database management technology, data custodians, query being expressed using both graphics and text means, modelling (numeric and logic based) being an intermediary in database access, and decision support becoming the user's requirement.

The established information industry sector which has catered to LIS requirements is the Geographic Information System (GIS) vendor. This is a small industry group which developed geographic data processing and data capture techniques for environmental and exploration data. They have traditionally ignored mainstream database developments because of the performance requirements which had to be met involving graphics data types. Mainstream database technology is now addressing engineering requirements such as GIS, and thus the sector can anticipate the development of general purpose database platforms suited to their requirements.

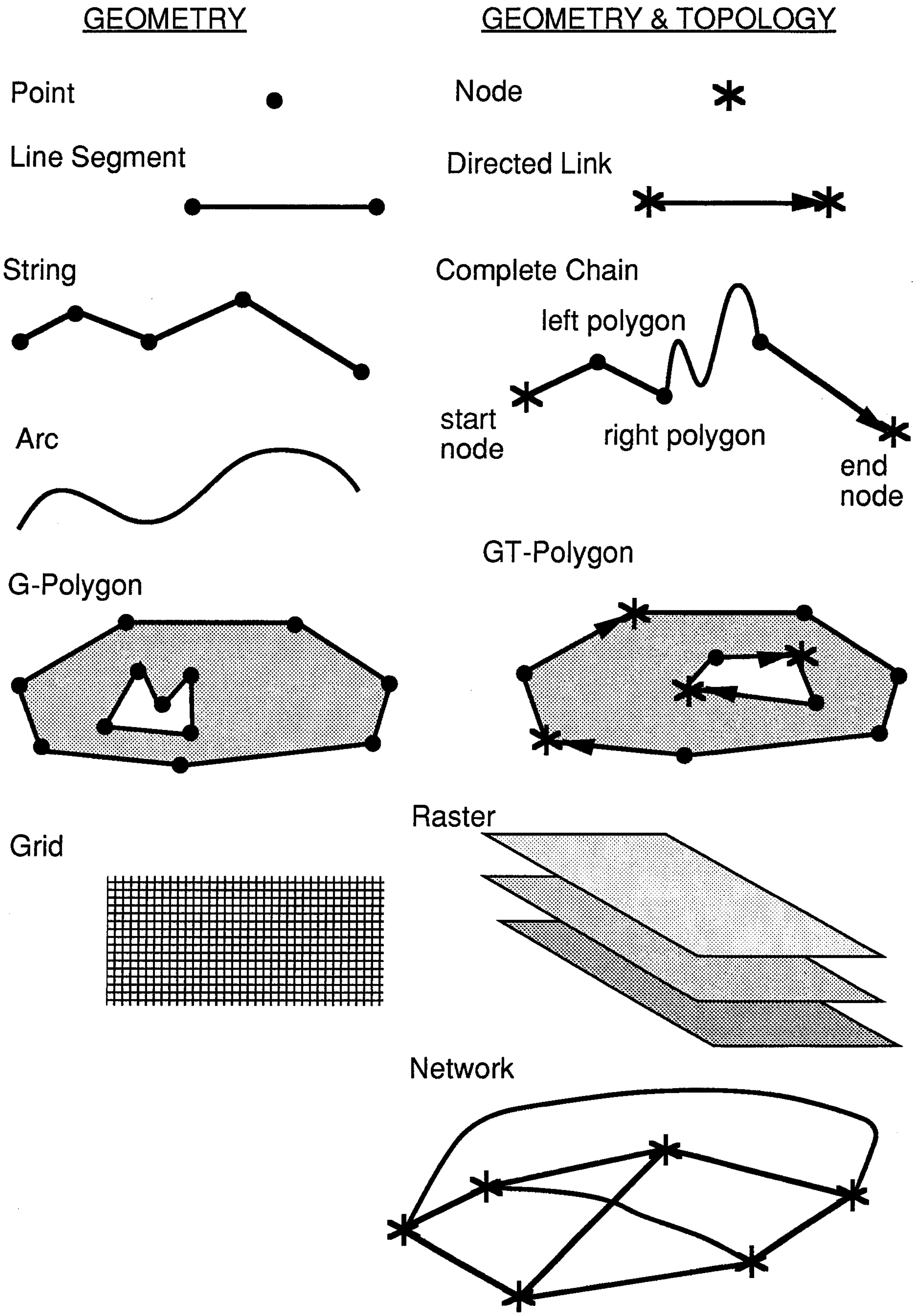

Figure 1: A representative subset of the SDTS Conceptual Model for Spatial Objects

SPATIAL DATA TRANSFER STANDARD

The move towards establishment of a standard for the interchange of spatial data (US Geological Survey, 1990) provides a consensus on the conceptual model of data currently of interest to the LIS community. This model uses the accepted terminology of entity and type, where an entity instance is considered to be a spatial phenomenon of a defined type. However as indicated by the conceptual models of grid and raster in Figure 1, the model also includes aggregates of data not corresponding to one particular real life entity. Figure 1 shows a representative part of the model concerned with what the SDTS terms the spatial object, which describes the location, shape, size and topological relationships of an entity instance.

The internal model for spatial objects is a complex object (see Carey el al 1988 and Scholl et al 1987). For example a line might reference its starting point node, its end point node, an ordered set of points defining the body of the line, and a number of other attributes.

The non-spatial component of the conceptual model is a relational model with a specification of how a spatial object and the relational components of an entity instance are to be related. Two types of relation exist: primary and secondary. Primary relations are like kernel relations (Codd, 1979) and the tuples are associated with spatial objects by using defined keys. Secondary relations correspond to association and characteristic relations (Codd, 1979).

A tuple in a primary relation may be associated with one and only one spatial object. Thus this kernel tuple maps to a unique conceptual entity instance having the associated spatial object. A spatial object may be associated with more than one primary tuple, thereby allowing more than one conceptual entity instance to have the same spatial description (eg a mountain and a trig station have the same geographic point location). Important semantic component of the relational model concerns the definition of keys, valid joins, and domains.

The SDTS model does not address some of the requirements LIS spatial data where full 3D modelling arises. In addition it does not address unconventional data types such as voice. Being solely a transfer standard the major database issues which arise with text are not addressed. Nevertheless it can serve to establish a data benchmark for spatial DBMS models and functionality.

LAND INFORMATION SYSTEMS

The generic properties of a Land Information System (LIS) are no different to the information systems which exist in other industries. In an attempt to accommodate a vision for the future of such systems a broad architectural sketch is shown in Figure 2. The ergonomics of modern information systems lie in the Graphical User Interface (GUI) which presents a visualisation of data in graphical and textual forms. The aim of the user is to access specified information, through models of real life situations which he explicitly or implicitly applies to the selected data.

As graphics workstations permeate the LIS environment most users are being insulated from the data models and data languages of the various data sources In specifying their requirements users will generally resort to a map of some sort showing the vicinity or topography of interest. This enables them to define their detailed requirements with a good deal more flexibility and effectiveness. The textual dimension has a role in specifying names and numbers, or in menus which present data and alternatives in that form.

At a lower level the information base is growing in content and complexity. Major LIS arise through a consortium of custodians of sectorial information. This is typified by the SLIC LIS Hub of the NSW Department of Lands (1986). The databases underlying these systems are now being loosely connected, but much work remains before the full spectrum of land data can be manipulated in a computerised information base.

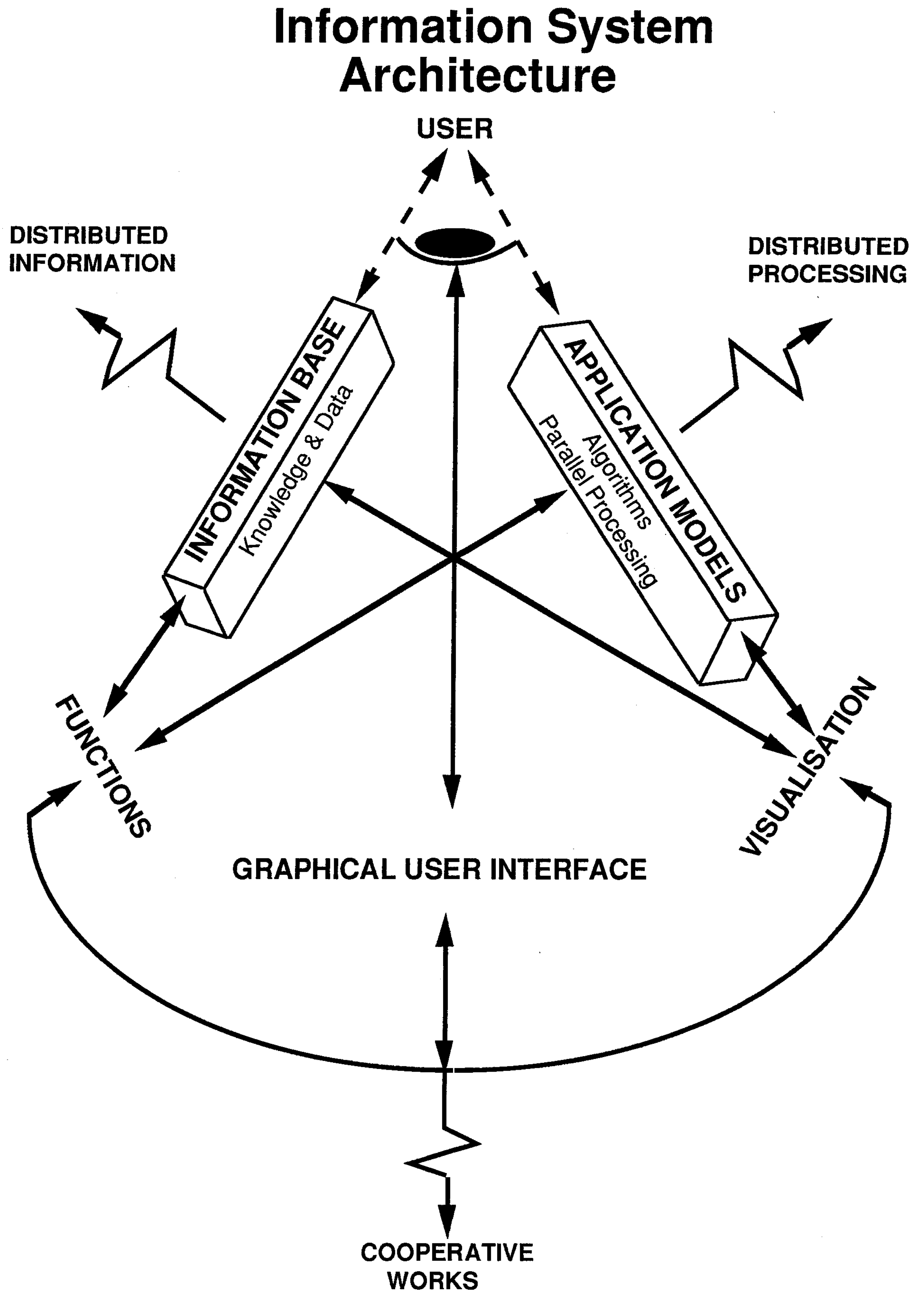

Figure 2: Computer System View of a (Land) Information System

The Role of Database Management

We referred above to an information base, relying on the reader's intuition of what was meant. Complex information systems such as LIS have diverse information forms not all of which can be committed to the data structures of a database management system (DBMS). However it is desirable that DBMS expand their capabilities to accommodate more of this information.

In this context a database is a collection of data conforming to well defined rules of representation and manipulation, usually specified in the schema and the associated controls of a DBMS. The DBMS provides a number of very important facilities for the management of large databases, which have evolved from an enormous collective effort and experience over the last thirty years. These facilities concern concurrent access, integrity and recovery, transaction management, programmable interfaces, database definition and evolution, data model and data language, query and user interfaces, performance, and distributed database. Some of these aspects will be taken for granted as we discuss the future directions of the technology.

One of the major claims for DBMS has always been that of data integration. This means that applications can relate data which would otherwise only be accessible by user intervention, involving completely independent systems. By supporting conceptual level data models based on entity and relationship, DBMS capture a deal of semantics for large databases. Thus they are beginning to be linked with the so-called knowledge based systems.

LIS Database Requirements

The basic LIS database requirements are to cater to the land data and applications defined in the first section of this paper. This means storing large volumes of 2-dimensional and 3-dimensional geometric and topological data, arising in both vector and aggregate (image, grid, etc) form. Performance is an issue, because of the amount of spatial data, and the search or indexing techniques necessary to support spatial qualifications.

Data integration is an important requirement. Land data has numerous sources and some of it is in textual form, for example that associated with land ownership, regulations, revenue and development. Statistical and survey data is usually more complex in structure than the usual commercial data. Thus at the conceptual level of design, entities are composite and complex in structure, and they lead to many object and data types.

By its nature LIS data will demand a distributed database, fragmented and allocated according to its inherent spatial distribution. On a different aspect, engineering design is typified by long and involved update transactions, often requiring versions of a database. In conjunction with networked graphics workstations, this may demand distribution of databases within a local area network.

The LIS Hub leads to more demanding requirements for distributed databases. These concern the integration of data across diverse and inhomogeneous DBMS existing with the independent custodians.

Because of the real life entities being manipulated, the user interface to LIS databases differs from the stereotype form of business transactions. In order to prevent the interface developments devolving into the application programs, the DBMS has to support the semantics of these real life entities in both data model and language extensions. In addition query facilities must exploit the GUI.

CURRENT STATUS OF DBMS/LIS

Since the inception of DBMS in the 1960s their development has been shaped predominantly by the requirements of business and commerce. The technology has focussed on the one general data type (formatted data) inside structures which can represent certain relationships amongst entities. In the 1980s the industry was penetrated by the relational (SQL) version of this technology. This has gained acceptance because of its simple data model and its ad hoc query capability.

From the point of view of LIS this evolution of DBMS technology has been a mixed blessing. A relation is a tabular data structure with columns composed of atomic values, and one, or several columns, comprising a key or unique identifier for each row of the table. In conjunction with the SQL language and its powerful relational join, this provides a clean programmable interface to a collection of related tables comprising a database. Unfortunately the first normal form (FNF) restriction that column values should be simple numerics or strings, does not allow the complex geometric objects (eg cadastre and regional boundaries) which are the norm in an LIS database to be handled effectively or efficiently.

The FNF restriction means that practically all LIS databases today are bipartite, being partly relational and partly controlled by a separate and non-standard system tailored to meeting the geometric/graphics requirements. This is a costly and awkward solution to a fundamental requirement. A notable exception to this situation is SIRO-DBMS (Abel, 1989), an extension to relational database systems which caters to many of the commonly occurring geometric entities arising in LIS.

The other types of land data mentioned earlier in this paper are even less well served. In particular no image database capabilities exist which address these very large uniform data aggregates and their corresponding spatial distribution. Nor are the less regular data, such as that arising from irregular grids and other sampling methods, catered for.

While relational DBMS have been expanding their capability to handle free form text as string valued domains, this type of text database facilities is most developed in special purpose text DBMS. A good example is the TITAN system (Thom et al, 1990). Recent advances in text systems provide intelligent subject matter recognition and inversion, but they have not been applied in LIS.

Distributed database capabilities are in limited use, catering to the formatted textual data of LIS. These capabilities are delivered in two ways. The first is within a completely homogeneous DBMS managing database fragments allocated to different sites. The theoretical issues of transaction management and query optimisation have been well addressed in the literature, but most operational systems only support remote relations in retrieval mode. The second way is conceptually simpler. Standards for Remote Data Access which define a generic interface to a DBMS are being supported, and networking protocols such as remote procedure calls can deliver remote access in the distributed computing sense (see Figure 2).

TRENDS IN DBMS

In this section the main directions for future database research are summarised. With different emphases, the summary largely parallels the ACM SIGMOD Record Volume 19 Number 4 which was devoted to the topic of Directions for Future Database Research and Development. The editor of that publication identified three main challenges:

"The first challenge requires significant additional research in various subdisciplines within databases, including object-oriented databases, extensible databases, spatial databases, deductive databases, database security, data dredging, database programming languages, and nonprogrammer's application development environments. The second area of challenge is global or multidatabase systems. The third area of challenge is parallel database systems and distributed database systems."

Interoperable Databases

There is a general realisation that the model of distributed database which has been implemented does not address the realities of distributed information systems. The distributed database problem is now seen to be that of heterogeneity and autonomy in a collection of databases. Thus the information that the user seeks is fragmented, and under the control of separate organisations, and hence it exists in independently defined and operated databases, which are connectable via communications networks. Ideally one would like to access the data with location and semantic transparency. This topic is called interoperability and it raises new problems as well as complicating old ones.

Much of the current research into interoperability is being conducted around two similar models for managing distributed, heterogeneous, autonomous databases. These are the federated database architecture and the multidatabase architecture. The ACM Computing Surveys Volume 22 Number 3 is a special issue on Heterogeneous Databases and those papers are recommended.

The basic and most difficult issue is that of semantic heterogeneity and schema integration. Each local database has its own conceptual schema which includes both structural and semantic constraints. However there is no established means for exchanging and integrating this meta data. Moreover not all relevant semantics are captured, particularly in the case of currently operational DBMS. Thus there has to be a further level of cooperation and protocol between DBMS and/or database administrators. In practice it is likely that only a partial level of integration will be necessary or desirable.

Once this basic integration problem is resolved the problems of language translation, query optimisation and transaction processing remain as significant issues in their own right. In addition scaling up to a large number of databases, having different availability and evolution behaviour, poses serious operational challenges.

Object-Oriented DBMS (OODBMS)

OODBMS is the meeting of the object paradigm, which arose in programming languages such as Smalltalk (Goldberg et al, 1983), and DBMS. Useful definitions of the core concepts are given by Atkinson et al (1989) and the ANSI X3 Project DBSSG/OODBTG (1990). A recent bibliography has been published by Vossen (1991). In the database sense an object can be related to entity instance, although often the latter may correspond to a composite of objects. The object paradigm is described in the following terms:

Encapsulation - is the clear separation between the external behavioural semantics of objects and the internal implementation. This black box specification is defined in terms of the behaviour of operations. An operation is performed by a method.

Message - an object is an operand of an operation (which may have several operands). If the object is the distinguished operand which is the recipient of an operation, the operation can be called a message and the other operands are the parameters.

State - of an object is implemented by internal data structures which change state as a result of state-changing messages. Some messages are just accessing operations. The result of a state-changing message will change the subsequent results of at least some messages.

Identity - provides a means to denote an object independently of its behaviour or state.

Type - defines the protocol of a group of similar objects which are instances of the type. This is the means of defining semantic integrity constraints for a database.

Class - is the implementation of a type. It defines the methods, messages and properties for the instances. The extension of a class is the collection of instances.

Composite object - is logically composed of other objects and operations propagate to the constituent objects.

Binding - is the act of associating an operation with a method.

Polymorphism - means that binding involves a choice amongst methods. Thus operations can be overloaded with alternative methods typically associated with different classes.

Inheritance - means new characteristics are derived from existing characteristics. Type inheritance graphs have unidirectional links showing the relationships whereby subclasses (subtypes) are specialisations of their superclasses (supertypes).

Extensibility - is the ability to define new types and classes, eg subtypes.

The object-oriented data model can be adapted to a database paradigm, although considerable research remains before a consensus on OODBMS will be reached. Some database characteristics such as transactions and recovery are largely independent of the data model. Current implementations of OODBMS have concentrated on achieving database persistence for objects generated in an object-oriented programming environment, in a highly effective manner. A link between object identifiers and references in programming languages has been forged, eliminating the "impedance mismatch" of SQL, and allowing highly efficient database caching to be achieved.

The relational model has a close connection with mathematical logic, enabling the development of declarative query languages such as SQL, and it enjoys a formal foundation. OODBMS have brought together computationally complete programming languages and databases to considerable advantage, but there is no well developed logic or language theory. Thus there is considerable debate in the research community concerning this vacuum.

One of the major elements missing from OODBMS is a query model and associated query optimisation. Accessing data encapsulated in objects, which can have complex structure, through methods built on a rich set of operators, poses a serious optimisation problem. There is no consensus on a query language and the closure property of relational query languages (the output of a query is relational) does not follow with class hierarchies and methods.

Transactions

Most concurrency problems are addressed by the transaction model. Research issues are concerned with distributed transactions (particularly in the heterogeneous database situation, see Breitbart et al, 1990) and with transaction hierarchies (Nodine and Zdonik, 1990). A related topic is the maintenance of versions of objects (see the bibliography of Vossen, 1991).

Spatial Databases

It is significant for LIS that the mainstream database research community has specifically recognised spatial databases as an important area for future research and development (Guenther and Buchmann, 1990). Areas which are being recognised by this research community include representation and spatial operations, spatial access methods, conceptual models, spatial query language and optimisation, precision and scale.

Integration of Knowledge and Data

Another general realisation in the information system research community is that artificial intelligence (AI) will have little impact until it is integrated with database technology and that these fields can be mutually enhancing. The problems in interoperability of database systems have exposed the weakness of database schemas in capturing and exchanging semantic information. Thus knowledge representation must be enhanced in DBMS for the purposes of a fuller integration and the support of high level user interfaces.

A frequent requirement of a general nature is for an active agent to monitor the contents of a database (it might be triggered by updates) and recognise certain "situations". A critical situation might be defined by a template comprising individual entity situations occurring in some overall relationship to each other. For example, a high frequency of accident reports at one location, in conjunction with recent changes at proximate locations, causes an analysis of traffic conditions and their control. The area of expert database systems is focussing on the organisation, control and execution of rule bases in a database environment, as a means of satisfying these requirements.

Deductive Databases

This is the special area in which logic and databases are combined (Ullman and Zaniolo, 1990) to extend the declarative programming style of SQL into a much more powerful language. SQL is generalised to be a rule based language in which goals as well as explicit retrieval requests can be expressed. For example if large lots are likely candidates for the erection of multiple dwellings, and if some zoning regulations permit the amalgamation of lots and the erection of multiple dwelling units, and if we recognise that adjacent lots under the same ownership are candidates for amalgamation, a simple logic program can recognise where multiple dwellings are likely to arise.

Deductive databases exploit both forward and backward chaining inference styles and it is useful if the system can automatically apply the more appropriate computation to a query. Current research is concerned with computing logic expressions which involve negation, and also with nonmonotonic reasoning and knowledge representation. There is now a move to associate this area with object-oriented and procedural paradigms.

Temporal Databases

Time as a fundamental concept is yet to be supported in DBMS technology. There is considerable research into models for its support. McKenzie (1986) and Soo (1991) published a bibliographies using a time taxonomy defined by Snodgras (1985): rollback databases (these represent transaction time and can roll back to any previous state), historical databases (these represent valid time and record when the stored information models reality, for tuple or attribute values), and temporal databases (these include aspects of time found in both rollback and historical databases). Snodgras (1990) identifies other future directions under language models, database design, inferencing, and real time (deadlines).

Security

Lunt and Fernandez (1990) classify research under discretionary security (based on the identity of users) and mandatory security (based on user clearance level). Implementation of mandatory security has led to the concept of trusted computer systems which is the theme of the 14th International Conference on Software Engineering, to be held in Melbourne 11-15 May, 1992.

Incompleteness, Imprecision and Uncertainty

Database research in this area is mainly based on the ideas of fuzzy relation, fuzzy value and similarity metrics. Research also embraces imprecise queries. This area is relatively inactive. Motro (1990) cites a number of pragmatic difficulties as additional reasons for the slow incorporation of capabilities into DBMS. (The crucial aspect in the LIS area is how application models cope with imprecise data.)

Extensible DBMS

With the advent of OODBMS there is now an effective means of extensibility available through the normal support for type/class. Carey and Haas (1990) discuss extensibility at the DBMS user level (eg query language) and the DBMS implementation levels (eg join algorithms, access methods). Extensibility at the lower levels threatens database integrity and this problem has to be addressed. Satisfactory operational support for adding extensions also requires further work. OODBMS will subsume extensible database.

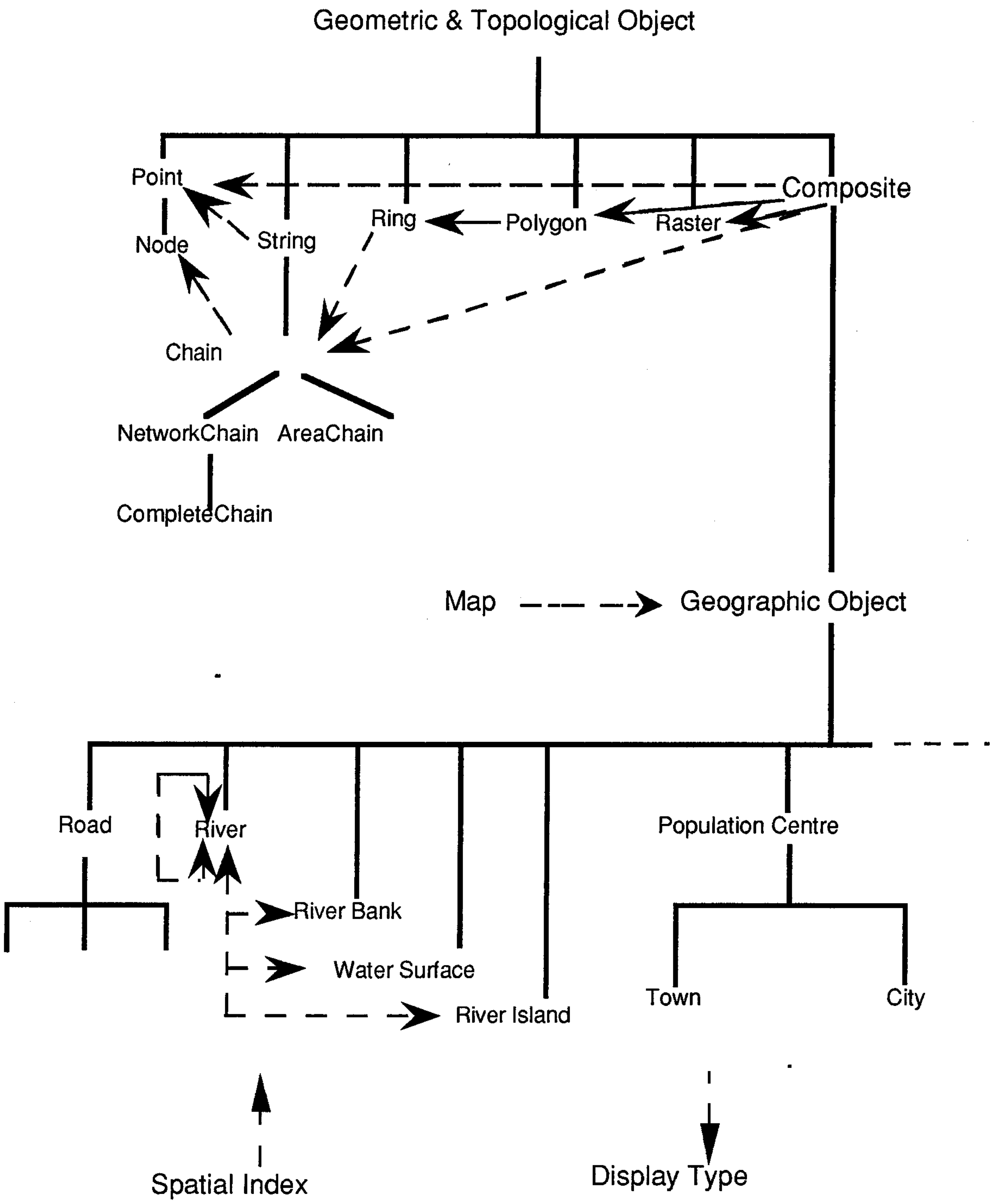

Figure 3: An inheritance hierarchy and references based on the SDTS model

Parallel DBMS

By the nature of the data model and the declarative nature of SQL, relational queries are highly suited to parallel execution. This has been exploited for certain types of relational database (DeWitt and Gray, 1990). Devising similar techniques for OODBMS is a research problem.

Directories

The directory problem has been best expressed by French et al (1990) in their paper on scientific database management. There is a basic problem in identifying and locating the data which does exist. Is the data relevant to the inquiry, and do useful data items exist for the particular purpose? The semantics of the raw data, its subsequent processing and interpretation, are critical to the potential user. Precision or imprecision are fundamental characteristics which must also be recorded at the meta data level.

FUTURE DATABASE MANAGEMENT FOR LIS

There are some important requirements and influences which will dominate the medium term future for LIS databases. These stem from the current state of GIS database technology which is the sector supplier, the large scale databases which are being generated, and the distributed nature of LIS systems. In addition, the demand for digital elevation models and an increased reliance on remote sensing for certain types of terrain data will result in data formats becoming predominantly raster and grid. The implications are now discussed.

Spatial Databases

The SDTS conceptual model described earlier presents a challenge for the GIS database systems serving the LIS sector. Their spatial DBMS capabilities do not meet expectations for storing and accessing databases reflecting the conceptual content of the SDTS model. In addition the current DBMS functionality is achieved through a bipartite approach, a fundamental barrier to performance and functionality.

In an experimental database development at the CSIRO Centre for Spatial Information Systems (Halstead et al, 1990), a spatial database conforming to the SDTS model was implemented using ONTOS, a commercial OODBMS (Ontologic, 1991). An early evaluation of this database implementation is given by Smith (1991). Using a terrain database (vector and text data types only) of complex objects (eg roads, rivers, contours, towns, etc) a 20 Mbyte database was established on a Sun Sparcstation 1+, using a design conforming to Figure 3 under ONTOS Version 2.0. (In Figure 3 full line connectors denote the inheritance hierarchy, and dotted connectors denote reference relationships.) The basic spatial data comprised more than 400,000 points (float * 2). To read the entire database into main memory using class (GIS layer) retrievals takes 4 minutes and 30 seconds. This is a rate in excess of 1500 points per second from a complex object database. That data rate will extend the display rate possible with many graphics packages operating on the same hardware. This experiment is clear evidence that object-oriented DBMS can deliver significant performance advantages and provide a single database approach to the requirements of LIS databases.

A number of other fundamental issues remain to be addressed in adapting object-oriented technology for spatial databases. Some of these concern extensibility, query, long transactions and versions, and the integration of knowledge and data. It is likely that much of the general research in these areas will be conducted in the object-oriented framework, and hence there will be likely spin-offs if LIS databases take this route.

Spatial access methods are a particular requirement still being researched. A number of useful techniques have been developed (eg Abel, 1989). It has already been demonstrated in the experimental system mentioned above that the same access methods can be simply incorporated as a class library in an object-oriented database implementation. Software reuseability will allow this to be exploited in other databases.

Images which have been subject to significant processing and interpretation will be stored as database objects. The extensible capability of OODBMS provides the opportunity to develop a generic image class library. This should include segmentation such as tiling, appropriate access methods and windowing.

Object-oriented programming, through encapsulation, inheritance and typing, provides a considerable software engineering advantage over older programming languages. By relating database object identifiers to references in the programming language, complex objects in the program execution environment merge with their database implementation. This provides a major performance advantage over the impedance mismatch of SQL and its server/relational cache implementation.

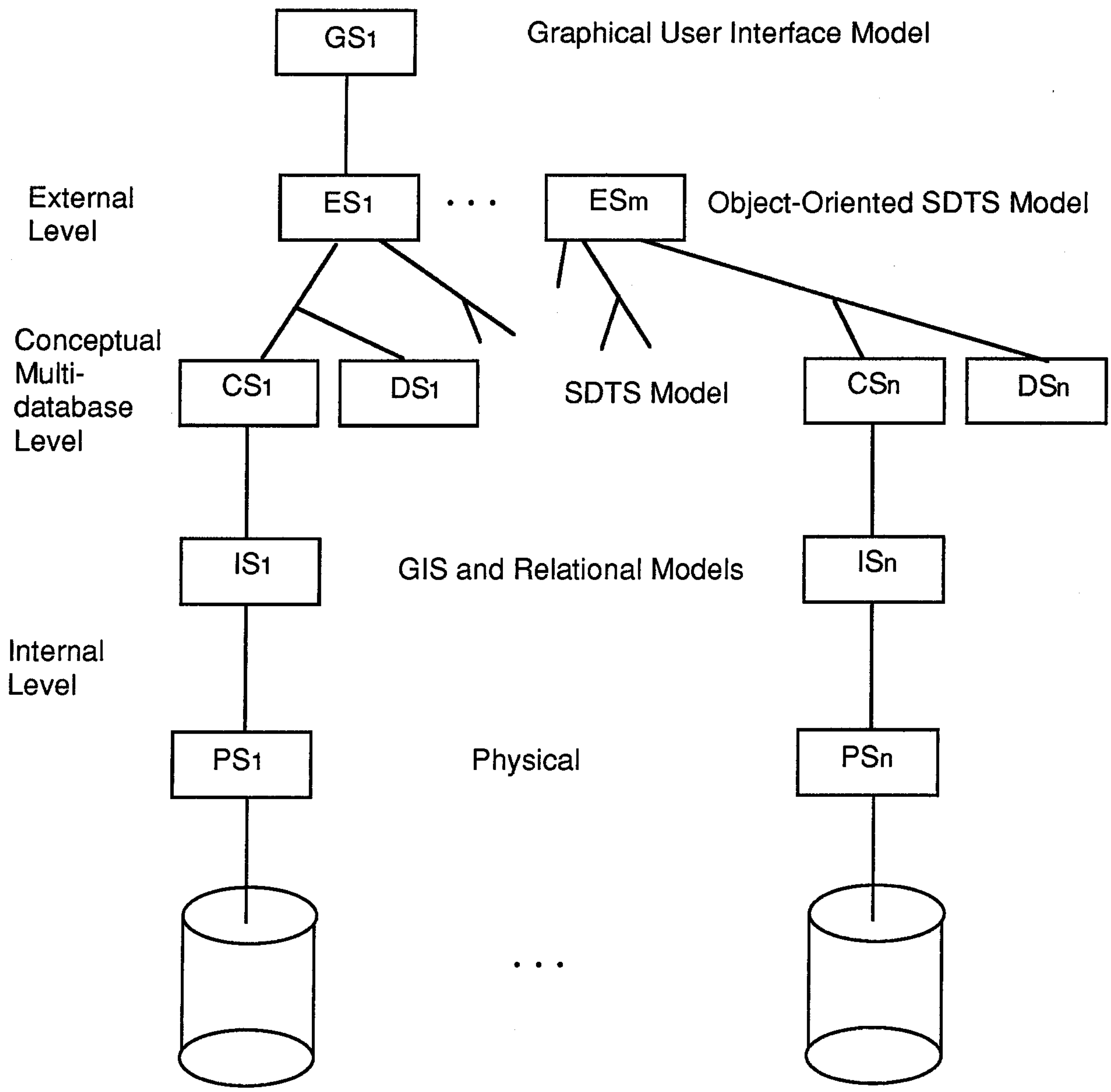

Figure 4: Multidatabase architecture, ES: external schema; CS: conceptual schema; DS: dependency schema; IS: internal logical schema PS: physical schema

The merging of SQL with object-oriented databases has been suggested. Implementations of SQL restricted to selecting from a single class are available (cf ONTOS). The main issue is how the join capability of this declarative language is to be provided for an object-oriented database model. One approach is to forego the doubtful advantages of the arbitrary join capabilities of SQL and to only exploit joins which correspond to defined references in an object-oriented schema. (The requirements of ad hoc queries are concerned with much deeper semantics than domain matching. These will only answered by developing deep knowledge representation.)

The prognosis for GIS database technology is that proprietary systems will disappear and the industry will adopt commercially available OODBMS.

Distributed Interoperable Databases

Although some of the important spatial databases will have their spatial and non-spatial data tightly coupled through OODBMS, LIS will still extend over multidatabases. Thus the problem of heterogeneous distributed databases has to be addressed in a context involving more complex objects than any other large scale information system. While general database research will address some important problems such as distributed heterogeneous transactions, the LIS research will have to address its own integration problem.

Schema integration must be achieved before any type of implementation can proceed. The industry is in the interesting position of having forged a draft standard for data exchange which not only includes a spatial model but also a relational model. The key to schema integration lies in having the semantic meta data necessary to complement the structural meta data present in database schemas. Semantic reconciliation concerns name conflicts and differences, domain conflicts, and attribute, relationship and role differences. A general solution is described by Papazoglou (1990) in terms of a knowledge driven approach. Realistic stepwise solutions will require the cooperation of database administrators in exporting and importing data definitions.

The multidatabase architecture defined by Litwin et al (1990) has been adapted to the LIS problem in Figure 4. The external schema level (ES) offers integrated views of various collections of databases, each defined for the purposes of certain applications. Each external schema presents a different view involving part or all of the selected databases. This clearly poses a more difficult consistency problem than the universal schema approach, however it allows a stepwise approach to interoperability in a context of autonomous databases.

In Figure 4 we propose that an extended SDTS data model be used for the levels involving interoperability. These are the conceptual multidatabase level where a local system exports that part of its schema it so desires, and the external level. The SDTS data model is being investigated for this purpose for two reasons. Firstly, as a draft standard data model it has addressed more of the problems of semantic reconciliation of data than any other proposal of its type. Secondly, given that it is adopted by the industry, some of the necessary tasks in interoperability will be addressed as a result (viz data mapping and data reconstruction using that model).

The conceptual multidatabase level will be based on the SDTS data model because the standard calls for the export of schemas using this model. However Papazoglou (1990) shows that an object-oriented approach to the external model offers certain advantages in dealing with the likely structural and semantic variations arising when classes (entity types) are used in more than one database.

It is unlikely that there will be any general approach to distributed update transactions in the heterogeneous environment until more progress is made on the integration problem.

CONCLUSION

LIS include a very broad spectrum of information and data types. They offer considerable challenge to database technology. Recent advances in object-oriented database technology will have an important bearing on spatial databases in this decade. The GIS sector will move its intellectual property base to modelling and graphical user interfaces, as databases become fully integrated under general purpose database technology. The manner in which SQL and logic will merge with object-oriented technology is not yet clear.

The number of public and private sector organisations which contribute to an LIS ensures that these systems will always be composed of distributed autonomous database modules. Interoperability is a particularly difficult problem which is only beginning to be addressed. The adoption of the SDTS model by the industry could have significant impact on interoperability because it could form the basis for a conceptual interface between autonomous systems. Operational and theoretical problems are likely to result in fairly slow and incremental progress in this area.

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GUAM ADDRESSES ON-LINE TRANSACTION PROCESSING IN A LAND INFORMATION SYSTEM - TITLES, PERMIT TRACKING and TAXATION

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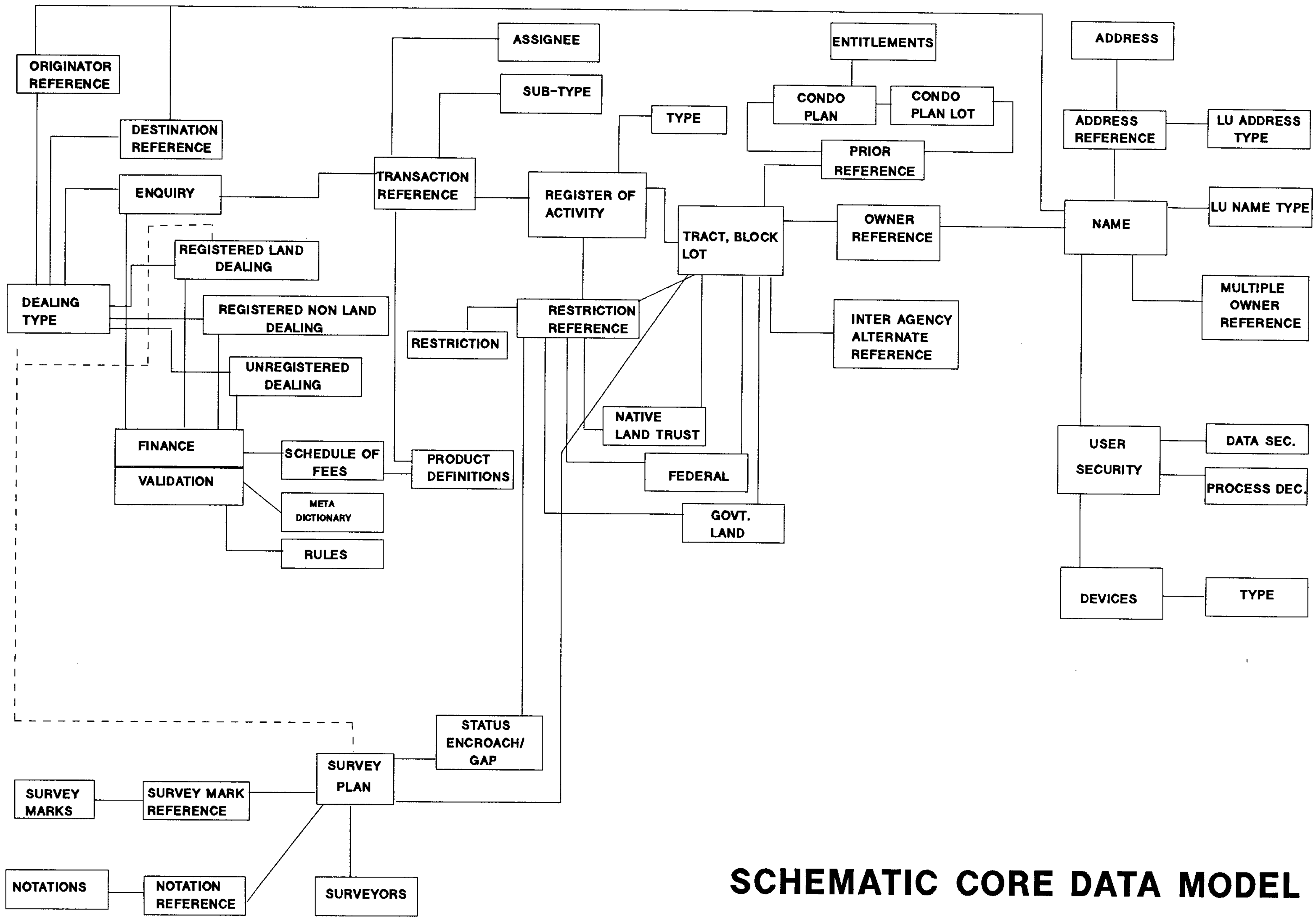
Abstract: The Island of Guam is isolated, governed as a Territory under the Organic Act and subject to California Law. Prior to Spanish occupation in 1583, and passage to United States jurisdiction with the termination of the Spanish Wars in 1898 there was a limited concept of individual land ownership by the Chamorro people. The Spanish circumvented the problem of local land succession by removing the Chamoro males, and the U.S. Government by declaring the island a Military Reserve. Individual land ownership began with the Granting of Estates to Spanish Families. The Chamorro were granted basic land rights in the early 1950's, Federal Properties being delimited by survey based on the 1945 survey network.

A boom in land prices as well as an increased local interest in land tenure has occured in the last decade as a result of overseas investment, primarily in the tourism industry. Guam is ideally located just three hours south of Tokyo, American and an established stop-over enroute from Japan to Australasia.

The process for the automation of land related records, entering land parcels by coordinate geometry, digitising lower precision data and developing an integrated LIS are underway. Rather than just mechanising the existing systems the decision was taken to develop a Corporate Data Model as the basis for all information systems required by the Department of Land Management. Priorities for the system include data, its collection and validation, information generated from that basic data and its integration in the service of the Government and the Public. The Guam Data Model is a pragmatic solution based on cost-effectiveness. The enabling software selected was GIS (GENAMAP), 4GL (UNIFACE) and data base (INGRES).

Land Tenure Systems are transaction based and the design (Figure 1) provides for O.L.T.P. using GIS technology for managing spatial referencing and providing visualisation and spatial analysis functions when required. Specific Applications to be addressed include progress towards an Automated Torrens Title System, lodgement of surveys, issuance of title, zoning issues, document management (land and non-land related) and permit tracking. Ramifications for property taxation, utilities infrastructure management and future use of the system by other governments for land tenure will be discussed.



SCHEMATIC CORE DATA MODEL

REF: 404:MM

MANAGING LARGE DATABASES FOR BUSINESS

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IBM Australia

Abstract

Database technology is crucial to the effective management of data within any modern business operation. As with any activity in business, successful exploitation of this technology in the long term requires the development of business based procedures with which it is to be supported. This paper provides a review of the issues associated with both the technology and the procedures and considers them in the context of Land Information Management (LIM).

INTRODUCTION

One of the most significant developments to have occurred within the broad framework of information technology has been that associated with database management systems(DBMS). Gradually, over a period of many years, models to facilitate effective data management have evolved from simple file structures to the highly refined relational model.

Data management lies at the heart of any modern business operation and is fundamental to its success. No large business operation could survive for more than a few weeks if its data management infrastructure were to fail and not be restored within a very short period of time. For many organisations the financial costs associated with failure for just a few days are enormous.

In terms of managing data, whatever system is employed, there are several basic requirements which are common. Broadly speaking these are the:

* maintenance of data integrity
* control of access to corporate data
* ability to share common corporate data
* ability to recover should disaster strike

Information technology has made such a dependence on data possible and in doing so created an equal dependence upon the management processes to support it. With more and more data being held, the complexity of the problem has increased at the same time as the importance of that data, to the business, has grown. Database technology and the business processes necessary to support it are closely linked, each being fundamental to the success of any large business. This paper is intended to review these issues in the context of large databases in the business environment with some consideration being given to the question of Land Information Management (LIM).

THE BUSINESS NEED FOR EFFECTIVE DATA MANAGEMENT

In order to better understand the issues involved in data management in business, it is worthwhile simply reviewing the business objectives which underpin the need for it.

The principal business need for data management is rooted in the expectation of the shareholders that the business will make a profit and provide them with a return on their investment. This is achieved through the management of risk and finances, tactical and strategic decision making, meeting customer requirements and establishing a market profile. One or all of these elements can provide an organisation with a competitive advantage and it should be clear that they all depend, to varying degrees, upon effective data management.

MANAGEMENT ISSUES

Management in the traditional sense of the word is crucial to the management of data. Since the objectives of data management are to facilitate the storage, retrieval, analysis and sharing of one of the most valuable of corporate resources the role of management is to ensure that it happens in a manner consistent with the objectives of the business.

Coupled with these objectives, management must also ensure that the strategies and support processes are in place. These are not narrow technical issues but require a wider business perspective. Because of the departmental origins of many Geographical Information Systems (GIS) these wider business implications are sometimes overlooked or given only superficial consideration.

Data Integrity

Maintaining data integrity is one of the fundamentals of data management since it is concerned with the accuracy or correctness of the data. A DBMS must preserve the integrity of the data and any failure in hardware or software must not compromise that integrity.

The preservation of data integrity is primarily dependent on the ability of the DBMS to lock records and fields as well as to test the validity of data that is being entered. An example of where such protection would be required is the case of an employee's details being entered against a department that does not exist. It is equally important that where changes are made to data, those changes are accurately reflected in other data with which there is an established relationship. This aspect of data integrity, in the context of a relational database, is called referential integrity.

When considering data integrity in the context of LIM it includes ensuring that graphics and alphanumeric data are maintained in synchronisation with each other. At the simplest level this means ensuring that when a graphic record is deleted the corresponding alphanumeric record is deleted, for example. This is an important issue where alphanumeric and graphical data are stored in separate databases since the system must ensure that this sort of synchronisation is maintained.

Synchronisation in this sense should be straightforward to achieve, but there are far more subtle issues in the same area. Suppose that an operation has been carried out which changes both alphanumeric and graphical data for an object, and that in the process of saving the results of the operation in the database(s), the transaction fails. If at this stage the graphical change has been saved but the alphanumeric change has not, then the two are out of synchronisation. The system must be capable of recognising this and either rolling back the graphical change which has been made or ensuring the alphanumeric change is also made. It would be extremely difficult to provide this level of data integrity in a system where the graphics are stored in their own data structure.

In a database such as DB/2, where a group of transactions are being carried out on the data base, they will not be committed until they have all been completed successfully. If the update process fails at any stage then all the updates which have been made will be rolled back so that everything remains synchronised.

Data integrity issues also arise if relationships exist between objects which have been extracted from the database for update and other objects which have not been extracted. This problem can be dealt with where the objects extracted are marked as "partially retrieved" and this then would restrict the type of update operations which can be done on these objects.

The situation where GIS data is available for query and update to a large number of users can further complicate the issue if the questions of security and data integrity are not taken seriously.

Security and Audit

Control over access to corporate data is an essential element of the risk management mentioned above. In particular, this data often comprises the competitive edge of the organisation.

Security defines the extent to which a user is able to gain access to corporate data while an audit facility provides a trail on which users have accessed which data. Together these features afford the basic protection an organisation must have for its information assets.

The three main types of access to data to be controlled down to the field level are update, read only, or no access. These categories may be subdivided further in the context of LIM update privileges. In particular, access to create entirely new data, the ability to make structural updates to existing data and the ability to update attribute data only. It is necessary to be able to grant these privileges at an object level since some users may be permitted to update or view certain objects but not others. This requirement applies equally to both graphical and alphanumeric aspects of the data. The DBMS must enable facilities to provide read, update, insert and delete authority on any data class for any user.

Back-up and Recovery

Regular back-ups of data are essential for any database system in order to be able to restore the database in the event of a major system failure. This includes a failure of the processor as well any device such as a disk drive or tape back-up unit.

The larger the database, generally speaking, the longer it will take to back-up, and therefore, there may be a reasonable length of time between full and complete back-ups. Transactions which occur after such a full back-up and before the next full back-up could present a problem should the system fail during that time. Transaction logging or journalling, as it is sometimes called, provides the ability to restore a system to a state which is more recent than that of its most recent full back-up. The transaction log can be saved on tape much more regularly than a full back-up can be done, since the data volumes involved are much smaller.

When restoring a database from back-up tapes, the most recent full back-up of the database is restored, and the transaction log can then be applied to this to bring it to the most up to date state possible. In more sophisticated databases, there are also facilities to back up individual tables or parts of large tables , so a full back-up can be done more quickly by running concurrent jobs to back up different parts of the database.

OTHER ISSUES

Concurrent Update

With many users seeking access to data the problem of concurrent update can occur. This is an area where GIS poses some more complex problems than simple alphanumeric applications. The native locking mechanism in standard database systems is based on the "short transaction". This means that if an application tries to access a record which is locked, the DBMS will wait until the lock is released and then return the data to the application. The underlying assumption is that the application that has locked the data will only do so for a short time. a few seconds at most. However, a record which is extracted from a GIS database may be checked out for hours or even days, so this approach is not appropriate.

In LIM, the solution to this problem relies heavily on management and communication between people rather than technology. Without going into great detail, data which is extracted for update must still be available to other users for viewing but not for update. Should there be a need for two users to each change the data, the user causing the contention can be identified and a resolution achieved by more conventional means.

Data Sharing

The ability to share common data is a primary benefit of database technology and an important measure of the effectiveness of data management within an organisation. One of the primary reasons for developing DBMS was the need to avoid a situation where each application owns its own version of the data, a concept which is countered by the application independence provided by a DBMS.

The objective of the "corporate" GIS must be to provide access to geographical data to those people who need it. This can often include a large number of users. Any user with a standard business graphics screen should be able to view the graphics for a selected area, update related alphanumeric data and perform simple forms of analysis. This type of facility would be much harder to implement if the graphics were not also stored in the database, especially as one starts to move to a distributed environment.

Distributed Data

The development of database software which can manage a database spread across multiple machines, in different locations, is something into which major database vendors such as IBM are putting great efforts. Various benefits come from being able to do this, such as being able to store each districts' data locally for improved performance and availability, while still being able to access data from other districts in a transparent way. Providing such distributed capability, while still maintaining the same function to manage data integrity and other issues is an extremely complex task. For example, the rollback capability mentioned earlier must be able to work across multiple machines. If a complex transaction makes an update on one machine and is about to make a related update on a second machine when the transaction fails the system must ensure that synchronisation is maintained between both machines.

The ability to provide a distributed database, with this sort of integrity is perhaps the biggest single argument in favour of storing all aspects of geographic data in a standard DBMS. The complexities of producing a true distributed DBMS are such that it is difficult to see how any GIS developer could justify taking on this task independently. If a non-database approach is taken and some data is stored outside the DBMS then it is not possible for the GIS to exploit any distributed function provided by the DBMS.

RELEVANCE TO LAND INFORMATION MANAGEMENT

The relevance to LIM in particular, is founded in the fact that most of the benefits that can be attributed to GIS implementation within an organisation, can only be delivered through effective data management. In most cases the GIS will include a large volume of data which forms part of a wider corporate information system. The following benefits of GIS can only be realised with good data management systems and business processes:

* Controlled access to data for large numbers of users
* Meaningful answers to "what if" questions
* Integration of data from different sources
* Improved productivity from access to common data
* Cost savings associated with common data

For these reasons alone the issues discussed are relevant to LIM.

Considering a more general business view, most of the organisations working with land related information and GIS are in the public sector. Here the traditional concept of competitive edge does not easily apply. When considering the decision making which occurs within the public sector, however, there is clearly a need for an information edge which supports the mission of the organisation. Technology forces change and this information edge is essential if the organisation is to demonstrate that it is best qualified to retain its current responsibilities or gather new ones.

CONCLUSION

There are, of course, many other issues associated with database technology which are indirectly relevant to the management of data in a large organisation. These include:

* Performance
* Availability
* Capacity
* Application development support
* Decision support

I have chosen to limit the discussion to those matters which are most directly relevant to data management in a large organisation.

This discussion has considered a wide range of database issues which apply to all corporate database systems, including corporate LIM. The requirements for LIM are essentially no different to the more generally understood requirements for information management. The key to success is in the ability to integrate data which, up until recently, has not been considered part of the traditional corporate information system but which is, none the less, essential for informed organisational decision making.

LAND INFORMATION MANAGEMENT IN URBAN AREAS

by

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ABSTRACT

The paper discusses the role of land information systems (LIS) in the management of cities; LIS in the urban context are defined, the reasons for having urban LIS are listed, the benefits of having urban LIS are discussed and problems of implementation are highlighted. The paper also considers the relationship between the establishment of a land information system in a city and a state or national land information system strategy.

THE CONCEPT

The concept of a land information system for a large city is simple to describe, however implementation of a LIS is very difficult.

In simple terms an urban LIS consists of the following:

(a) A common geodetic reference framework to which all land-related information is referenced;

(b) A common base map(s) which is used to record different land-related data;

(c) A set of standards which is adopted by all the participating agencies in the city and which defines such things as land parcels, parcel identifiers, land title details, buildings, building identifiers, facility identifiers, names of roads and buildings, road boundaries, street furniture and similar items;

(d) A lead agency responsible for preparing and updating the base map and common overlays;

(e) An executive steering committee comprising senior personnel from the participating agencies responsible for policy and funding arrangements;

(f) A technical committee from the participating agencies which is responsible for making recommendations to the executive steering committee on appropriate standards, coordination strategies and funding mechanisms. This committee should ensure that the data bases and map layers produced and updated in the participating agencies are capable of being integrated or overlaid;

(g) A funding arrangement from all participating agencies which meets the cost of the standard base mapping and any technical support needed by the executive steering committee. Basically, a "user pays" approach is adopted; however, funding is shared with regard to the cost of producing the standardised base mapping. The cost of preparing or maintaining map-based data or textual data which is unique to an individual organisation, is the responsibility of that organisation; and

(h) An education and applied research strategy which ensures that there are adequate trained personnel at all levels to design, develop and maintain the land information system. This strategy should be fully supported by the executive steering committee. The implementation organisation for education and applied research should work closely with the participating organisations and the technical committee.

LESSONS FROM DEVELOPING COUNTRIES

Often in a developed society, with sophisticated administrative system in our cities, we find it difficult to recognise fully the importance of a coordinated approach to managing our land-related data. As a result, sometimes for political expediency, governments make short-term decisions to cease some government services previously considered essential or at best re-structured such that the long term effect is the same. This has happened in the past, particularly with regard to the preparation and updating of a common base map for cities. For example, in Victoria at present, the Government appears to be of the view that market forces alone will continue to service the needs of the state in this regard. History has shown this to be very undesirable.

The above view can be implemented for perhaps a decade, as a state continues to rely on the good work of the past. However, in the long term, very serious damage is done to the management of land and services, particularly in the cities. In such circumstances it is valuable to look to the experiences of some developing countries, where the importance of a coordinated approach to land management in urban areas is very obvious. In this regard I am drawing on my experiences as a Land Information Consultant in the Urban Research Division of the World Bank, in Washington DC, in 1989/90 (see Williamson (1991) and Holstein (1990) for further details).

There is increasing recognition that cities are the economic engines of the Third World. For example, approximately 60% of GNP of developing countries comes from urban areas, even though these areas contain only about one third of the total population in such countries. Also, about 80% of the growth of GNP of developing countries is in urban areas. Over the past three or four decades, the urban population in the Third World has increased from less than 300 million to about 1.3 billion. In 1989, the urban population in developing countries increased by some 45-50 million as compared to 7-8 million in developed countries. Up to the turn of the century, the cities and towns in the developing world will have to absorb another 600-700 million people, or about two thirds of the world's total population increase (World Bank, 1988).

Despite progress in some areas, the urban environment continues to deteriorate in most developing countries. The managers of cities are trying a whole range of techniques to improve the quality of life and are "running harder and faster than ever", but they are continuing to slip further behind. One obvious indication of this is the rapid expansion of informal settlements, with poor infrastructure facilities and dilapidated houses. Other signs are increasing congestion, air and water pollution, and deteriorating infrastructure. Simply the rapid urbanization has outstripped many, if not most, governments' ability to provide even the most basic of services. As a consequence, the major international aid and lending organisations, and their borrowers, have to tackle the serious distortions which exist in the financial, land and housing markets.

There are large inequities in most Third World cities, where, as a consequence of poor mapping and land administration systems, a large number of well developed properties are not paying important taxes. It is not uncommon to find luxury apartments with swimming pools and tennis courts, while the road outside is often unmade and gets flooded regularly, and the basic services and utilities are in a very poor state of repair. Simply, if the city administration does not have an up-to-date record of property; does not know where it is, who owns it and its value; it is difficult to tax land and property equitably. Without an adequate tax base it is difficult, if not impossible, to fund essential infrastructure and services. At the same time, if a city does not know the location of all existing services, it is difficult to repair and upgrade them. Other consequences of poor land management include the inability to undertake any city planning or acquire land for public facilities. Land information systems are seen as one method of helping overcome these urgent problems.

In the cities of the developed world we take a lot for granted. We often forget the importance of of efficient, effective and economic land administration and management systems in our cities. If we ever need a reminder of the vital nature of these systems, we need only look at the cities of the Third World.

JUSTIFICATION FOR LAND INFORMATION MANAGEMENT IN URBAN AREAS

Land information systems are not just hardware and software. They are a complex arrangement of:

- People;
- Politics:
- Institutional arrangements;
- Procedures;
- Information technology;
- Data bases.

As shown in developing countries, LIS are a critical part of the land administration and management system of any city. LIS provide an infrastructure for linking or networking land-related systems within a city. On the other hand, a generally accepted view of geographic information systems (GIS) are that they are more a tool, are more project oriented and are more concerned with hardware, software and data.

There are many reasons for introducing the LIS concept in urban areas.

- Standardised base mapping will enable better delivery of public services, especially through the ability to combine data for such uses as valuation of real estate, land tax, planning, facility management, environmental impact assessment, land acquisition and cadastral administration. This will also enable better analysis of data and consequent planning for public services.

- Standardised data arrangements to improve the ability to share and exchange data between organisations.

- A formal data management system to improve the updating and consequent timeliness of data.

- Standardisation reduces the initial cost of developing the map based and textual data bases and the cost of updating that data through sharing the costs

- Standardisation ensures adequate standards and quality assurance are maintained

- Standardisation minimises duplication of effort in maintaining land information

THE ISSUES

In developing a strategy for a land information system for urban areas, there are many issues to consider:

Coordination and management The development of land information systems in urban areas is primarily based on the need for coordination of the major information providers, resulting in a common vision and common objectives. This reduces duplication and increases efficiency. Coordination is however only part of a good management.

Leadership Coordination cannot be achieved without leadership and goodwill. It is as simple as that!

Common base map After coordination and leadership, the basic principle of a LIS for an urban area is the need for a common base map. If institutional and funding mechanisms can be found to prepare and maintain a common base map for use by all the key users in a city, then the major obstacle in developing a LIS strategy has been overcome .

Urban vs Non-Urban - The dichotomy The Urban vs Non-Urban debate can be very complex. In general, "Urban" is concerned with parcel-based and utility data, while "Non-urban" is primarily concerned with natural resource, environmental and agricultural data. This dichotomy is important in the design of a state or national strategy rather than an urban strategy. In addition, in the developing world, there is an on-going debate as to the contribution that the two sectors make to a national economy.

LIS/GIS being technology driven There is a great danger that land and geographic information systems are technology driven rather than being driven by user needs. This is a particular concern in developing countries where there is often a lack of knowledge and understanding about the associated LIS/GIS technologies.

Deregulation The present trend towards deregulation will make it increasingly difficult to control LIS in a traditional legislative or regulatory manner. Coordination will have to be by a mechanism which is in the interests of all parties; in other words, cooperation not regulation.

Privatisation, cost recovery and the role of the private sector Cost recovery and financial accountability are moving all persuasions of government in Australia to privatisation. No longer can LIS/GIS be driven solely by government with "lip service" given to the private (and academic) sectors, as in the past. Any new LIS coordination approach must consider privatising government functions where applicable, and recognising the role of the private sector to a greater degree.

Copyright Government must fully embrace copyright laws with regard to land-related data and the issues of cost recovery. However, recognition must be given to the position of the USA, where any data which has been collected with taxpayers' money is free, except for charges relating to copying the data, etc. This is still a major issue which has not been fully resolved in Australia.

Legal liability Issues of legal liability with regard to use of land-related data are being considered by government LIS institutions however the associated difficulties have not been overcome.

Politics Any initiative which involves a number of different organisations in sharing information becomes a political issue. Every organisation wishes to protect its "turf" and its staff, unless there are strong reasons to do otherwise. Simply, the importance of having a "tireless champion" who continually works to ensure there is something for everyone in a project or who continually reminds all partners that the initiative is in their long term, cannot be over emphasised.

Dichotomy: privatisation/cost recovery vs standards The major arguments against a totally free market or "laissez faire" environment are duplication and a lack of standards. The latter reason has become increasingly important as we move into an information society. *Appropriate* standards are critical for the success of a land information system. As a consequence, this creates a demand that there is some coordinating mechanism which can set such requirements.

Influence of the utilities One of the major influencing factors which is, amazingly, overlooked in the design of a LIS in urban areas, is the influence of the utilities or, to put it bluntly, the influence of those organisations which require land-related information, and especially map-based data, and are financially independent of government. More often than not it is these institutions which set the priorities in LIS and must therefore be accommodated. Otherwise, they simply go away and undertake their own initiatives, which in the long term may not be in the interests of the city.

Cost-benefit Whatever criticisms can be made about cost-benefit analysis as a methodology, it is a sobering mechanism which forms an integral part of any initiative in today's society. Quite often, the cost-benefit process is more important than the outcome, as long as the cost-benefit ratio is favourable! It must be recognised however that the application of cost-benefit analysis to land information management is very difficult, especially regarding the quantification of the benefits.

Total Quality Management (TQM) TQM is a management technique which is rapidly gaining in popularity. In simple terms it consists of doing "things right the first time". Any new LIS initiative should incorporate TQM in the implementation strategy.

Education and Research As distinct from many other Western countries, government in Australia has traditionally given only given "lip service" to tertiary institutions; there has been a culture of doing any training and research internally. This has been the case particularly in the surveying and mapping area. To a large extent, this has been facilitated by government being able to fund such activities from their own resources. At the same time government departments were usually much better equipped with the latest technology than were the tertiary institutions. The tertiary institutions were seen as not particularly useful, except for educating personnel at the undergraduate level. Many government organisations preferred not to even acknowledge expertise or resources in tertiary institutions; it was as if there was a view that by ignoring the tertiary institutions, they would go away and not be a bother. The current economic environment has changed all the above. Government, especially in the professional and service areas, has been reduced by financial cuts. The tertiary institutions in surveying and mapping, however, have tended to become stronger, better equipped, more highly attuned to market forces and more vocal. Ten years ago there was one Professor of Surveying in Australia; today there are seven. Ten years ago the tertiary institutions were not very interested in government policies and systems which had an impact on the broad community; today they are very interested and demand to play a role. Recognising the financial constraint on government and the resources and expertise available in universities, government cannot afford to ignore this sector as in the past.

CASE STUDY - METROPOLITAN MELBOURNE

The early 1980s saw the development of a comprehensive land information strategy, called LANDATA, for the State of Victoria. A state organisation, also called LANDATA, was formed to coordinate the implementation of the strategy. The strategy covered the coordination of basic parcel-based data, topographic data and natural resource data. Initially the implementation was aimed at the development of a system to link the identification of parcel-based data across such organisations as the Land Titles Office, the Board of Works, the Land Tax Office, the Valuer General's Office and local government (Phase 1). In parallel was the development of a digital cadastral data base for the State which commenced in 1985. LANDATA was located in the Department of Property and Services, together with the Land Titles Office, the Division of Surveying and Mapping, and the Valuer General's Office. LANDATA was directed by a senior steering committee comprising the CEOs a number of the producers and users of land-related data in Victoria. The future looked good for Victoria, albeit it was recognised that the State was starting a little behind some of the other states such as South Australia and Western Australia. The vision, the institutional arrangements, and in general, the necessary broad based support were in place to ensure that Victoria would develop a land information system of world class. Other Australian states and many overseas countries recognised the sound planning and vision of LANDATA.

While the LANDATA concept was not directly concerned with the management of metropolitan Melbourne, it was the central strategy in developing a land information system which served the needs of the metropolis. In this regard the then Melbourne and Metropolitan Board of Works (now the Board of Works) was given a key responsibility for this urban area. Under another agreement the Board of Works was responsible for all large scale cadastral mapping in metropolitan Melbourne. A key component of LANDATA was the linking of the LANDATA index with the Board of Works property files and the then Ministry of Planning's parcel-based data bases. Local government, and particularly the urban councils, were originally seen as an important target for LANDATA. However as time progressed it became increasingly difficult to get all the independent councils to share a common view of LANDATA due to each having it's own views and information strategy (or lack of it). In the early days of LANDATA, the advantages and benefits were difficult to quantify to councils which often had a very short sighted view with regard to the management of spatial data. During the late 1980s, the local councils became increasingly interested in spatial data and particularly the development of digital cadastral data bases however in general the councils were not prepared to invest large resources in such an initiative. At this time the Board of Works started providing data at minimal cost to urban councils and assisting them in establishing their data bases, although the progress continued to be slow. Now as a result of a policy change, the Board of Works have privatised elements of their organisation and are charging for the data, the establishment of systems has slowed further.

The latter half of the 1980s saw a gradual and continual narrowing of the focus of LANDATA, which resulted in mounting dissatisfaction from many of the users and some of the contributors of land-related data in the State. By 1990, there was little strong leadership, direction or coordination in Victoria for the management of land-related data linking parcel-based, topographic, natural resource, utility and socio-economic data. The results of the general dissatisfaction were a government review of geographic information systems being called by the Premier's and Cabinet Department and an extensive review of LANDATA called by the then Minister for Property and Services, Mr Ian Baker, both in late 1990. The LANDATA review was completed in April, 1991, with the GIS review commencing in May, 1991. The reasons which led to the dissatisfaction and consequent reviews are many and varied, with some of the more important factors being as follows.

(a) During the latter half of the 1980s there was an increasing awareness of the importance of cost recovery and accountability of government services. When LANDATA was established, the original cost/benefit analysis justified its development based on savings in the user agencies. This justification was changed when the Government moved through the phase of adopting cost recovery principles to requiring profit based exploitation of it's information assets. In order to achieve these latter objectives in the Department of Property and Services, LANDATA increasingly focussed attention on potential revenue raising initiatives, such as the Public Enquiry Service in the Land Titles Office. As a result, LANDATA had virtually given up coordination and leadership of land-related data, in the broadest sense, in the State of Victoria by 1990.

(b) During the mid- to late- 1980s LANDATA commissioned advice from the land information system organisation of Sweden. The advice from the consultants reinforced the move to narrow the focus of LANDATA to the Land Titles Office and particularly the Public Enquiry System. The consultants also encouraged a move away from an emphasis with the DCDB and other spatial data. I am not convinced the consultants' advice was in the long term interests of LANDATA or the management of land-related data in Victoria. As pointed out in Williamson (1987), the Swedish land information system is a world leader however it's focus is very narrow. It is only really concerned with an automated land titles system, not a land information system as perceived in Australia. It is not concerned with a supporting DCDB. In most cases the Swedish system is supported by a graphical cadastre. The underlying cadastral system and the associated institutional arrangements in Australia are very different to Sweden thereby making comparisons very difficult.

(c) The responsibility for maintaining the vision and implementing the strategy of LANDATA rested with one government department, the Department of Property and Services. It was justifiably not fully committed to a strategy which covered many government departments, the tertiary sector and increasingly the private sector, in the changing political environment dominated by the need for government austerity.

(d) The LANDATA Steering Committee, for much of the late 1980s, did not meet and was not effective in giving leadership and coordination. It also had a relatively narrow membership which did not include the academic and private sectors or many of the users outside government.

(e) LANDATA was given a poor financial performance rating by the Auditor General in 1989, which increased the emphasis of LANDATA on cost recovery and financial accountability. Even though the Auditor General's report was refuted in Parliament, it did leave a cloud over LANDATA's financial performance.

(f) As a result of the increasing pressure from government, in the late 1980s, LANDATA became increasingly narrow in focus and more inward looking. This was similar to the environment surrounding the development of the Torrens Registration Automation Project (TRAP) in the NSW Land Titles Office in the mid 1970s. In the early days of LANDATA, the staff did a very good job of promoting and "marketing" the LANDATA concept. This essential function became increasingly lost as LANDATA narrowed its focus. As more pressure was put on LANDATA by the user community, the more LANDATA became inward looking. This simply compounded the problem.

(g) Even though LANDATA was only resourced by the Government to undertake a relatively narrow mandate during Phase 1 and at no time was approval given to broaden it's mandate to fully coordinate all land-related data in the State, ***this was an expectation of the land and geographic information community.*** Simply there was no other initiative in Victoria giving leadership and direction, as in many other states, and as a result users looked to LANDATA for guidance and leadership. Unfortunately LANDATA was not given the mandate for this broader role nor funded to undertake such a role.

(h) Much of the concept of LANDATA was predicated on the free exchange of land-related data. However, towards the end of the 1980s there was increasing emphasis on full or partial cost recovery, with the result that some of the fundamental principles of LANDATA were no longer valid. LANDATA was not able to solve the very difficult problems of charging for land-related data.

(i) In 1990, the land information arm of the Board of Works was privatised which put increasing pressure for a review of LANDATA. It should be recognised that by 1990, the Board of Works had completed digital property mapping for metropolitan Melbourne.

(j) As LANDATA narrowed its focus to the Public Enquiry Service in the late 1980s, the users of natural resources data became increasingly vocal in their criticism of LANDATA. This dissatisfaction came to a head with the Premier's and Cabinet Department announcing a review of GIS for the State. At the same time, other bodies, such as the Victorian Law Reform Commission started expressing dissatisfaction with the performance of LANDATA.

(k) In the early to mid-1980s, LANDATA and the Division of Surveying and Mapping, worked very closely on joint research projects with the tertiary institutions in the State, and especially with The University of Melbourne. During the late 1980s both The University of Melbourne and the RMIT became increasingly involved with research into land information systems. However due to tight budgets and a narrowing of focus, LANDATA increasingly distanced itself from the tertiary institutions.

(l) As a consequence of the increasing concerns of the user community, and the continuing concern in the government about the perceived unreasonable cost of LANDATA, the Minister announced an enquiry into LANDATA in late 1990. This review however was one of many which has sometimes put unreasonable pressure on LANDATA. Through out LANDATA's existence, it has has experienced approximately one major review per year.

With public recognition of the economic problems of Victoria and a change of the Premier in late 1990, the Department of Property and Services was abolished. The Land Titles Office was transferred to the Attorney General's Department, and the Division of Surveying and Mapping and LANDATA were transferred to the Department of Finance. These changes present certain problems, including the Public Enquiry Service and the maintenance of the DCDB being separated from the Land Titles Office, however MITS continues to update its DCDB. Of interest the Department of Finance is negotiating with MITS to purchase the DCDB for metropolitan Melbourne. The Department of Finance will then keep it's DCDB up-to-date through changes recorded by the Land Titles Office.

The LANDATA review has acknowledged the problems associated with the management of land-related information in Victoria, and that LANDATA had basically become the Public Enquiry Service within the Land Titles Office, by the end of 1990. The review however has vindicated LANDATA's financial performance and return on investment, especially through the utilisation of it's computer assets by running a bureau service and from the cost savings from computerising the creation of the DCDB. The report has recommended a range of initiatives, including the partial privatisation of the Public Enquiry Service and the establishment of a Land Information Council funded by the "user pays" principle. At the time of writing, however, the Minister for Finance has not acted on the recommendations.

Without the establishment of some coordination mechanism in Victoria the problems which led to the review will continue. If this doesn't occur the market place will decide, which may not be in the best interests of Victoria. Considering Victoria's economic woes however, it is understandable that the reform of LANDATA is not a high government priority.

Such a result is undesirable, since to the best of my knowledge, all states, jurisdictions or countries in the developed world have some level of coordination of land-related information by government. Victoria may never reach a completely market driven environment, however, the trends to full cost recovery, privatisation, deregulation and smaller government will ensure that the management of land-related information will in future be based to a far greater extent on the pressures of the market place and less on "public good" considerations. To say the least, the future for the coordination of land-related information in Victoria is uncertain.

It is ironic that the Surveyor General has had to "step into the breech" and give leadership through the development of a strategy to manage spatial data in the State during the last year or so. His initiatives are making a positive contribution which it is hoped the Government will fully support for the betterment of the State. His vision is one of the really positive initiatives on the horizon.

The above review highlights the importance of a state-wide land information management strategy in developing a land information strategy in a large metropolis. The two are closely linked and cannot be separated.

CASE STUDY - BANGKOK

The strategy to introduce a land information system into the City of Bangkok has many lessons for both the developing and developed countries.

The City of Bangkok has had many consultants undertake studies during the past decade to determine an appropriate strategy to develop a land information system for the City. There was one fundamental weakness in all these studies. They were all done by overseas advisers or organisations under a variety of international aid programs. None of the studies were undertaken by the Thai organisations themselves, although they fully cooperated in the studies. The overseas organisations came into the country, did their study, prepared a report and left. The result was that little of the experience of these LIS studies remained in Thailand. These studies were, however, critical in raising the level of interest and commitment for the Bangkok Land information System (BLIS).

Due to the magnitude of the problems in Bangkok and the resulting size and complexity of any proposed land information system, the key Thai organisations in the City of Bangkok came together to undertake their own study and pilot project called BLIS. It was recognised that the over-riding objective of the BLIS project was that the relevant Thai organisations gain experience in designing and building their own systems.

A summary of the objectives of the BLIS Project are as follows.

(a) Education, training and the gaining of experience of Thai Government officers in the key organisations required to establish a future computerised land information system for the City of Bangkok.

(b) The determination of an appropriate common base map for the City of Bangkok which could be used by all organisations that will be developing land information systems in the City. Without doubt this is the most important technical objective of the project. Thailand had recognised the importance of cooperation in developing a LIS for the City. Senior Thai Government officials had visited Australia, Canada, Sweden, Germany and France and seen the importance of such cooperation. Even though the necessary cooperation between agencies in all these countries is not always the case, the Thai officials and all the overseas studies emphasised the importance of one common base map and a cooperative effort in developing such a map.

(c) The establishment of an operational pilot land information system for the City of Bangkok.

(d) To ensure that a future land information system for the City of Bangkok will include efficient record-keeping systems for land-related information.

(e) To better understand the existing land information processes in the respective authorities.

(f) To improve the effectiveness and operation of the participating authorities.

(g) The Project has an important objective of determining an ***achievable*** long term strategy for the development of BLIS. From the overseas studies, from visits, from attending conferences, and from LIS/GIS vendors, the Thai officials have seen many highly developed and complex systems. The big question for the City of Bangkok was to determine what is possible, and what are the priorities in establishing a LIS for the City. Simply, many of the systems and approaches put forward from developed countries may not be applicable to a rapidly expanding city of about ten million inhabitants in the Third World. The project has a clear objective of determining what is ***possible***. The long term strategy will address such questions as:

- how should the base map be prepared?
- who should prepare it?
- who should manage the updating of the map?
- who should pay for the preparation and updating of the map?
- what should be included in the base map. Should it only be topographic data or should it also contain land parcel data. Should it contain all buildings?
- should any attribute data be included on the base map?
- should the private sector be involved in the preparation of the base map?
- what are the priorities in developing the LIS?
- what institutional arrangements should be put in place to facilitate and encourage coordination when each authority wishes to develop its own system in house?

There is a clear recognition by the Thai officials that if the system gets too complex it has little chance of success.

(h) Obviously, a very important requirement of the project is to determine the structure of the future LIS. It is important to remember that there are a large range of data gatherers and data users in the proposed system, all of which have different needs. For example, the utility authorities are not particularly interested in the land tenure and land parcel base. They wish to have a map of all the roads and buildings so they can show their services and customers. On the other hand, parcel information is vital for land tax and planning, although a considerable amount of tax is raised from levies on buildings. All these activities are at a nominal scale of 1:1,000, although there is an increasing awareness in the Bangkok Metropolitan Administration (BMA) Policy and Planning Department of the need for a smaller scale GIS based based on existing 1:10,000 scale maps.

(i) A key goal of the pilot project is to determine what technology and sophistication is required for the establishment of a LIS for the City of Bangkok. It will be important to evaluate software and hardware maintenance and the reliability of the systems in Bangkok. Already in the project, problems have arisen with regard to the applicability of some technology. This experience is very valuable for the future.

(j) It was quickly realised that education and training of staff in all the relevant organisations would be a key in the long-term success of BLIS. The project will have to assist in the development of a ten-year education and training strategy for the introduction of LIS/GIS. Such a strategy will require major input from the academic institutions already involved in LIS/GIS in Thailand, such as the Department of Surveying Engineering at Chulalongkorn University. In addition it will certainly require short-, medium- and long-term programs both in Thailand and overseas.

The Thai Government Steering Committee for the BLIS Project realised that in the short term there was not sufficient experience in Thailand to undertake the pilot project. As a consequence Thailand asked for assistance from the Australian International Development Assistance Bureau (AIDAB). The assistance provided is a full-time Land Information System Adviser for two years from the Overseas Projects Corporation of Victoria (OPCV) and a Senior Adviser and Project Coordinator on a part-time basis from the consulting arm of The University of Melbourne (UNIMELB). These advisers are not undertaking or managing the BLIS Project. They are simply drawing on their experience in establishing similar systems in Australia and overseas to give advice where required.

The over-riding success of the project to date is the recognition that a LIS for the City of Bangkok will only be possible if the key agencies cooperate and coordinate their activities through an integrated approach. This is a lesson that many other countries in both the developed and developing world should heed.

Even though the BLIS Pilot Project has only completed the first year of a two-year program, there are a number of key lessons to be learnt from the project's operation thus far.

(a) The most important achievement of the project to date has been the confirmation that the development of a common digital base map able to be used by each of the agencies is both essential and feasible.

(b) It is important for the respective authorities to make a significant commitment of money and staff to the project. Without such commitment, it may be difficult to maintain the long-term support of the authorities.

(c) One of the most difficult aspects of the project has been the establishment of an independent Thai Government Unit within the BMA to manage the project, however once established, it gained a momentum of its own which was essential for the project to proceed. As in any government organisation world-wide, the establishment of a new office and facilities to support a high technology project with over twenty staff is not easy. The success of the project to date is due to the perseverance of a number of key senior Thai Government officials who fully support and believe in the project.

(d) The Australian advisers have had a key role in the establishment of the project. The experience of the full-time adviser has been very important. In addition the three-monthly visits of the Senior Adviser have allowed the project to focus on its performance against the Work Plan on a regular basis. Without the support of AIDAB for the project, it is unlikely that the project would have progressed as planned.

(e) A key to the success of the project has been the full support of Thai Government officials at the most senior levels. This support has come from the most senior elected officials, as well as the permanent government officers in all the participating authorities. Without this support the project would definitely not have commenced.

(f) The importance of undertaking a comprehensive ***pilot project*** is proving a very worthwhile decision. Already a significant number of directions with regard to identifying a common base map and the appropriate associated indexes, and the methods of capturing and maintaining that data, are becoming evident. The pilot project is certainly confirming the view that the establishment of a comprehensive land information system is not easy and has to overcome many technical, institutional, management and personnel problems.

(g) It is very heartening to see the Thai authorities taking a long-term view of the creation of BLIS. They are placing significant emphasis on the determination of a ***clear and simple*** vision for the future. The pilot project will ensure that the vision and the long-range plan are reasonably achievable.

(h) Already, the pilot project has highlighted the very real differences between digital mapping, land information systems, facility information systems (FIS) and geographic information systems, and the different user needs associated with each of these systems. Simply the user needs and requirements for each of these systems are ***not*** the same.

(i) The pilot project is highlighting the different needs for education and training. At the operator/technician level there is a requirement for basic training on the system. At the professional level there is a large range of requirements, generally divided between operation and management of the system. It has proved relatively easy to train officers within a month or so to use the computer system. It will, however, take a least a year of education to teach the scientific, technical, management and institutional theory underlying the development and operation of LIS/GIS/FIS.

(j) The cooperative effort between the key land management authorities in the City of Bangkok is proving very successful, however it has been important to give feedback on the project as soon as possible. In this regard the project organised a comprehensive seminar three months after the equipment was commissioned, which proved to be very successful in maintaining the momentum and profile of the project.

(k) It is essential that the contract for the hardware and software for the system includes appropriate full-time technical support by the vendor. This ensures that the software will be used appropriately and efficiently, thus saving a lot of time and effort of project personnel.

(l) It is essential that an appropriate mechanism is established to ensure that suitable and on-going policy and technical directions are given by middle management to the usually junior technical staff operating the system. Such direction is very difficult to maintain over the period of the project.

(m) A high-level working steering committee, which has input from all the participating organisations and which meets regularly, is essential to the success of the project.

(n) In any project where there are a number of independent organisations, such as BLIS, it must be accepted that different organisations have different priorities, funding sources, objectives and implementation schedules for the long-term development of their own systems. It is essential that the steering committee manage these different demands to ensure a continued commitment to such basic LIS principles as a common base map. It is very easy for an organisation to believe that "everyone else is too slow" and that they should "do it alone".

(o) Continual promotion of the project in the form of seminars, demonstrations, displays and articles is essential in maintaining support for a project such as BLIS.

(p) Care must be taken that organisations do not interpret early outputs from the pilot project, such as demonstrations, as implying that the ease of developing a pilot project can be transferred into a permanent institutional system. In reality, pilot projects are relatively easy to develop compared to the development of a permanent, institutionalised system. Simply, technology does not solve administrative and institutional LIS problems.

(q) Within the BLIS project, it was much easier to establish the technical rather than the administrative infrastructure. Even with a major commitment from the most senior officials, it will take over one year to set up the administrative infrastructure (tables, telephones, secretary, photocopier, etc.) to support the project.

(r) The input of both graphic and textual data has taken considerably longer than planned and has required substantial software "tailoring".

(s) Difficulties are being encountered in comparing the existing maps from the participating agencies. They are often not up-to-date with the latest digital base map, which is derived from recent aerial photography.

CONCLUSION

There are many similarities between developing a land information management strategy for urban areas, and developing a national or state-wide LIS strategy. However, there are some very important differences. The concept for a LIS strategy for urban areas as described is simple, yet difficult to achieve without a major effort. The justification is also simple and logical.

Cities in both developed and developing countries have difficulties in creating a working LIS. It is very easy to take for granted the systems that have taken a century to put in place in Australia for the management of our cities. However, the review of LIS for urban areas in developing countries does give a clear insight into the importance and role of LIS for urban areas in general.

As pointed out, the justification for LIS for urban areas is clear, but the implementation is not. There are many issues which must be considered in developing a LIS for urban areas, with such issues as coordination, leadership and a common base map being at the forefront.

In order to better understand the role and development of LIS for urban areas, two case studies have been carried out; one for metropolitan Melbourne (population about three million) and the other Bangkok (population about ten million). These case studies highlight the importance of an appropriate strategy in developing a LIS in different types of urban areas. The Bangkok case describes a successful strategy to mount a pilot LIS project. However, the eventual outcome of a long term LIS is by no means certain. The case of Melbourne has many positive and negative lessons in how to go about developing a LIS. From the Melbourne case study in particular, it is evident that an urban LIS strategy is intimately linked with a state-wide land management strategy.

What is certain is that land information systems in the appropriate form are vital for the effective and efficient management of our cities, especially in the current age of an information society.

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APPLYING HIGH-SPEED COMMUNICATIONS TECHNOLOGY TO SPATIAL INFORMATION SYSTEMS: ADDRESSING MANAGEMENT CONCERNS

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ABSTRACT

Introduction of high-speed broadband telecommunications systems promises to remove one of the major barriers to implementation of real-time spatial information networks within geographically-scattered organisations. However, it is still unclear what implications this technology will have in land information management arrangements and system performance over metropolitan- and wide-area networks. Until both the potential customers and providers of such technology gain a clearer understanding of the performance and management issues involved, the rate at which organisations will adopt such technology remains uncertain.

This paper summarizes the results of a study identifying factors which encourage or inhibit the use of these broadband technologies in land information networks. In addition, it introduces one approach now being undertaken to predict performance of higher-speed telecommunications networks in a land information management environment.

INTRODUCTION

Geographic Information Systems (GIS) technology has largely grown out of an "end-user computing" environment catering to the requirements of relatively small, centralized groups of professional specialists in the facilities management, natural resources and cadastral mapping fields. Management attention in such programs is now shifting from *data collection* to database maintenance and development of new services for a growing user community. Once suitable data coverage is available and preliminary applications have been tested, making the database available to remote users becomes an important objective.

Most land information networks currently in operation have been concerned with transferring textual data from a dedicated host computer to remote terminals. LOTS in South Australia is one example of this [Sedunary, 1988]. Only recently have some networks – such as the Western Australia Land Information Access Network [Bennett et al., 1988] and Sydney Water Board's IFIS network [Chapman, 1991] begun transferring large volumes of vector and image data as well.

Crosswell [1986] reported that most North American GIS organisations surveyed at that time were transferring spatial data via magnetic tape or diskette. A more recent study indicates that Australian organisations involved in geoprocessing activities *still* transfer much of their spatial data files to remote users and/or outside customers in the same manner [Newton et al., 1990]. Due to relatively slow transmission rates and narrow bandwidths, bulk file transfers of GIS graphics and image data across dedicated telecommunication lines have been prohibitively expensive. More importantly, the long response times have limited the practicality of carrying out complex analyses and real-time remote database inquiries.

Introduction of higher-speed telecommunications systems promises to change the way these organisations transfer and utilise such data. Important examples of new developments in this field include:

- *Integrated Services Digital Network* – ISDN is now offered by telecommunications services around the world and provides customers with end-to-end data transmission rates of 64 K bits/sec and higher;

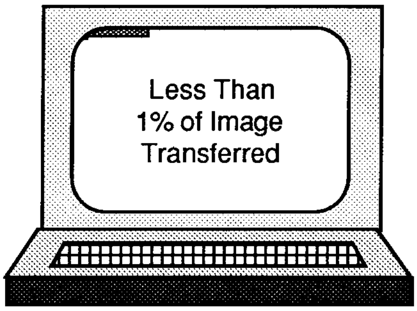
- *Metropolitan Area Networks* (MANs) – MAN services like Telecom Australia's FASTPAC will provide high-speed (up to 34 Mbit/sec) packet services between local area networks (LANs) and offer interface speeds comparable to those of the LANs themselves (10 Mbit/sec).

- *Broadband ISDN* – B-ISDN promises to provide customers with 155 Mbit/sec access via optical fibre to a broadband network capable of supporting high-speed data and high-quality video services. Detailed standards for B-ISDN are expected in 1992 and commercial services are planned for Australia sometime after 1995.

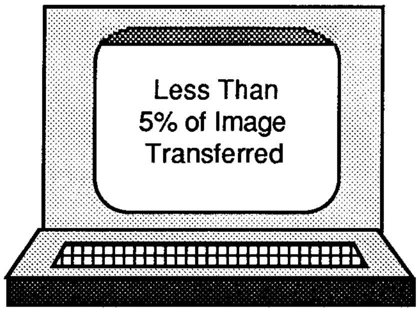
Figure 1 indicates the relative speeds of these new technologies in comparison with existing network services and illustrates the effect these speeds will have on display times for uncompressed images.

Service	Speed Range	Speed of Example	Transmission Time to Fill Sun 360 Workstation Screen
Telephone Modem	300 - 9600 bit/s	4800 bit/s	1.4 hours
ISDN	64 K bit/s	64 K bit/s	6.3 minutes
FASTPAC	2-34 M bit/s	10 M bit/s	2.5 seconds

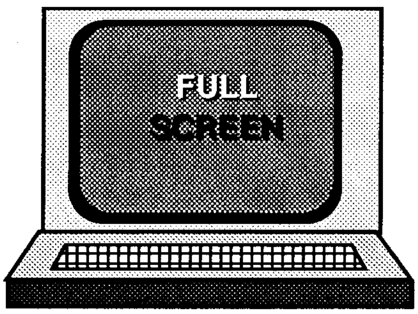
Comparative Times Required to Display a 24 Mb. Image on a Sun 360 Workstation Screen



Telephone Modem @ 4800 Kbit/s



ISDN @ 64 Kbit/s



FASTPAC @ 10 Mbit/s

Comparative Portions of 24 Mb. Image which can be Displayed on a Workstation Screen in 15 Seconds

Figure 1

Comparison of Transmission Speeds
Using Alternative Communication Technologies
(Based on figures provided in [Cavill et al., 1989])

By employing such technologies, users may finally enjoy access to and usage of remote databases and resources in geographically-scattered organisations within acceptable response times. However, it is still unclear what implications this technology will have in land information management arrangements and system performance over metropolitan- and wide-area networks (WANs). Until both the potential customers and providers of such technology gain a clearer understanding of the performance and management issues involved, the rate at which organisations will adopt such technology remains uncertain.

Telecommunication Requirements in Land Information Management

In 1990, Telecom Australia commissioned an investigation into the characteristics and communication requirements of selected users in the GIS, land information systems (LIS), automated mapping/facilities management (AM/FM) and computer-assisted drafting (CAD) sectors [Newton et al., 1990]. This paper discusses the results of that investigation and identifies factors which encourage or inhibit the use of broadband communication technologies in land information networks. In addition, it introduces one approach now being undertaken to predict performance of FASTPAC networks in a land information management environment.

Case Studies

Subjects selected for case study included a cross-section of organisations involved in land and geographic information systems, remote sensing, AM/FM, CAD, medical imaging and electronic document interchange (EDI) technology. In all, individuals from approximately 25 major government organisations, private companies and institutions were interviewed.

Factors Influencing Adoption of Broadband Communications Technology

Factors Facilitating Adoption

Case study interviews also identified factors which could be expected to act as either *facilitators* or *inhibitors* to the penetration of FASTPAC following its commercial release in 1992. Major factors facilitating the penetration of higher performance telecommunication technology include the following:

(1) *Growth in Data Volumes*

Raster scanning of subdivision plans and digitizing of cadastral data will dramatically increase the size of LIS databases previously limited to textual data. (A typical property map image file can be 16 Megabytes in size.) In remote sensing, receipt of up to 1200 Gigabytes of satellite imagery data *per day* is anticipated as users deal with increased resolution of satellite imagery, a growing number of satellites in use and more organisations offering the data itself.

(2) *Growth in Data Sharing and Distribution*

Utilising data collected from different sources in order to reduce duplication of effort and generate new information products has been the *raison d'etre* of corporate land information management efforts for the past fifteen years. The current development of *land information directories* in various jurisdictions around the world is evidence of market demands for concise information describing contents of spatial data held by various organisations. AUSLIG's on-line Land Search Directory, the National Resource Information Centre's (NRIC) FINDAR system, and the Environmental Resources Information Network (ERIN) all represent operational or proposed examples of such directories in Australia.

(3) *Increasing Demand for Real-time Systems*

Hardware improvements have brought about dramatic improvements in processing speeds, memory, storage, and graphics capabilities over the past 30 years. In effect, these new capabilities have altered *user expectations* regarding minimum "acceptable" response times for particular computer-based operations. However, relatively slow data transmission speeds and narrow bandwidths have constituted bottlenecks to real-time network operations.

To help identify candidate organisations most likely to benefit from adoption of technologies like ISDN, FASTPAC or B-ISDN, the investigators classified organisation types in the LIS/GIS/Remote Sensing and CAD communities according to two criteria:

- *Perishability of the data which the organisation maintains* to support the application or programme; and

- *Level of need for interactive processing or display* over MANs, WANs or global networks

Table 1 classifies the organisations and summarises the applications under review according to these criteria.

(4) *Increasing Demand for Secure Data Transfer*

Security of host data has been a major stumbling block to electronically linking databases in the past. From a legal perspective, the means of authenticating document images transmitted across a network is also regarded as being a problem at this time. However, new high-speed telecommunication services offer a much higher degree of security through data encryption (even on public switched networks). Indeed, given recent examples of "fax tampering" reported in the media, such transactions have the potential to be even more secure than these existing services in the future.

		Data Perishability	
		HIGH	**LOW**
Need for Interactive Processing or Display over Metropolitan-Wide-Area or Global Networks	**HIGH**	Type I Organisations *Existing applications already requiring high-speed data communications capabilities* e.g. Weather Monitoring & Forecasting National Defence Remote Surveillance Emergency Despatch Vehicle Fleet Management	Type III Organisations *Most GIS applications currently fall into this category.* e.g. Regional Planning Conservation & Environment Municipal Planning & Engineering Forest Inventory & Management Soil Surveys & Monitoring
	LOW	Type II Organisations *Real-time processing already carried out in-house on LANs. Data transmission to remote sites on magnetic tape or diskette via courier.* *These organisations likely to migrate to Type I status, but first require sufficient justification for real-time distributed analyses and faster file transfer to remote centres.* e.g. Medical Imaging	Type IV Organisations *Little or no change over time in the information content of data supporting these particular disciplines or applications.* *Coverage of relevant areas can be stored on optical disk for use in the office or in the field.* e.g. Exploration Geology

Table 1:

Two-Factor Classification of Differing Organisational Demand
for High Speed Communication Networks
[Newton et al., 1990]

(5) *Integration of Telematic Activities and Applications*

As telecommunications move into an era which permit integration of voice, text, data and images, applications are emerging to take advantage of such network capabilities. Examples include linking text documentation and specifications with CAD drawings, linkage of subdivision lot plans with owner details on title documents, and combination of image, text and possibly voice communication for GIS consultative planning applications.

Major Factors Inhibiting Adoption

The following factors will influence how quickly users will either adopt and/or upgrade to broadband communications services.

(1) *Availability of High Speed Communications Infrastructure*

Broadband telecommunication services will generally require access to a *fibre optic infrastructure*. Telecom Australia is now carrying out an optical fibre cable replacement programme, and, over the next few years, several million homes and businesses throughout Australia will find themselves within 2 kilometres of optical fibre service [Hunter, 1991].

(2) *Legal and Regulatory Issues*

At present, legislative requirements in all states dictate the provision of hardcopy documents to support applications in such areas as planning (e.g., Ministry of Planning, Victoria) and land title registration (e.g., LANDATA in Victoria) [Newton et al., 1990]. Private organisations also rely upon the legal security afforded through possession of hardcopy documents.

Similar problems concerning legal admissibility were faced by the micrographics community a decade ago. The EDI (electronic document interchange) community is now addressing this matter via Trading Partner Agreements. However, until similar arrangements or changes in legislation are introduced in Australia, all value-added network providers face the same barrier for certain applications.

(3) *Data Interchange Standards*

As discussed in [Zwart, 1991], lack of a widely accepted international standard for interchange of graphics data represents a current bottleneck for land information exchange and an inhibitor to cost-effective real-time data transfer between organisations. (After all, how useful *is* a 10 Mbit/sec connection when subsequent file reformatting can take hours or even days on a time-shared computer?).

In remote sensing, SPOT and LANDSAT have cooperated in adopting identical formats. After several years of deliberation and review, Standards Australia's IT-4 Committee on GIS — in cooperation with the Australian Land Information Council (ALIC) — has proposed adoption of the U.S. Spatial Data Transfer Standard (SDTS) and its modification to meet the needs of Australian users. Even so, SDTS has not yet been optimised for real-time data exchange across telecommunication lines [Clarke, 1990].

BROADBAND COMMUNICATIONS AS AN AGENT OF ORGANISATIONAL CHANGE

The investigations indicated that the introduction of broadband telecommunication networks is highly likely to change the way that LIS and GIS information is organised, networked and managed. One of the major drawbacks to using the distributed network model for LIS and GIS activities is that system management and control issues become more difficult and complex. Such matters as database updating, quality assurance, data exchange, distribution and security are difficult to manage in a distributed environment. As there are no operational systems of this type at present, most of these management issues have not been adequately defined or addressed. They are, however, of major concern to most systems administrators. Centralised processing – with intelligent remote terminals linked by a fast, high capacity communication network – *may* present an attractive alternative by simplifying system management procedures.

TOWARDS MORE RELIABLE USAGE AND PERFORMANCE ESTIMATES

How quickly organisations involved with geographic information processing will develop the need and justify the adoption of higher-speed technology in their communications networks requires additional study. Data traffic patterns, volumes and the demand for higher-performance communication links in a given organisation will vary according to the type of network model adopted. Similarly the telecommunications expenditure of the organisation will also vary with the network structure adopted. In order to ascertain the likely network strategies that the GIS/LIS community will adopt in a broadband communications environment calls for further research.

Follow-on studies are now being carried out by representatives from Telecom Research Laboratories, CSIRO Division of Building Construction and Engineering, and the Centre for Spatial Information Studies (CenSIS) at the University of Tasmania. To assist in the analyses, a number of "standard" network models, data sets and spatial data handling operations are being defined to act as a baseline against which to measure & compare network data traffic and flow in different organisations. The results from these experiments will be combined with data from representative GIS facilities in outside organisations in order to obtain the most reliable indicators possible at this time. Outside organisations participating in this study include the Victoria Department of Conservation and Environment, the Tasmanian Forestry Commission, LANDATA in Victoria and the Sydney Water Board.

SUMMARY

LIS/GIS programme demands are already changing from data collection and initial application development to data dissemination, servicing of remote users and more widely-distributed database management. Rising levels of expectation regarding processing and display speeds across local area networks are already pushing demand for higher-speed LAN solutions, and these demands will soon spread to transactions between users in central and regional offices across metropolitan- and wide-area networks.

In the longer term, experience has already shown that operational necessity and the sheer common sense of sharing data (inside *and* outside the organisation) will eventually overcome bureaucratic obstacles, institutional differences and technical diversity. The technology already exists, the necessary infrastructure will be in place, costs will move to competitive levels, and the way organisations manage and work with their information will change accordingly.

For the time being, however, operational concerns and the lack of comprehensive spatial data transfer standards optimised for telecommunications represent serious barriers to the adoption of broadband communication technologies. Studies now underway through CenSIS and TRL should provide further information concerning the existing and predicted nature of land information network data traffic and thereby enable Telecom Australia to develop more reliable market predictions regarding this sector.

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EDUCATION AND TRAINING FOR LAND INFORMATION MANAGEMENT - ITS CHANGING NATURE

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ABSTRACT

The functions undertaken by land information managers, the demands being placed on their information resource and the technology they employ are all evolving. The paper discusses these issues and their implication for education and training courses in land information management.

INTRODUCTION

Modern land information management (LIM) practice and the spatial information technology on which it rests is neither mature nor static. Rather it, and its supporting technology, are evolving in concept, form, function and extent, such that neither LIM practitioners, the researchers, nor educators can afford to be complacent about their knowledge and expertise in the subject.

Australia is reasonably well endowed with formal education and training courses in LIS/GIS at university and technical college levels. While some institutions have been offering courses for over a decade, others have only recently started. It is suggested, however, that all, to a greater or lesser extent, are failing to keep pace with the evolution of these information systems, their management and use. The nature of these changes and their impact on course content and teaching styles are the topic of this paper.

BACKGROUND

Land information management is the function of providing land related information to groups of users in a form and of a type required by them to complete the task at hand. This function calls for the supporting land information systems (LIS) to have the necessary coverage, content, compatibility and reliability of information. Further, more users must be able to access the information, and integrate it with their own data to satisfy particular needs [Dale and McLaughlin 1988].

The primary task of the land information manager is to ensure this information is available on request. It is therefore necessary to have a programme in place which collects and stores the requisite data, and retrieves and communicates the relevant information to the user in the desired form. In short, the ultimate goal must be to ensure availability and access to a resource of information of known extent and quality to meet the needs of users more efficiently, effectively and equitably.

To achieve this goal, information is generally conceived to be a corporate, organisational resource to be managed like people, money and property through an information resource management (IRM) strategy [Davis and Olson, 1984]. Such a strategy needs to identify, and locate, the organisation's information resources, formulate information policies, standards and procedures to build and manage the resource. Issues similar to those proposed in the Australian Land Information Council's national strategy [ALIC 1990] need to be addressed. Implementing such a strategy requires, according to Sedunary [1991], people with broad based skills particularly in two major areas

- "an intimate knowledge of the whole information production pipeline - all land data collection processes through to the understanding and meeting of end-users information needs.

- skills in data administration - all those particular processes involved in protection of the corporate data or asset, ensuring its ongoing integrity."

For this discussion, two aspects of these LIM personnel skills are important: (a) familiarity with the technology of the production of land information products, and (b) familiarity with the organisational context, needs and applications of the end-user of their land information services. This paper suggests that both are changing rapidly and these changes should be reflected in the education and training programmes.

THE CHANGING NATURE OF LIM

Information Production

LIS, whether computer based or manual systems, have a data capture, data storage, data manipulation and data presentation component. In addition, if the system is being converted to digital format, there will be data conversion activity. Figure 1, compiled as a result of discussions with a number of state agencies responsible for *programme* mapping and for natural resource inventories, illustrates the proportion each activity occupied between the years 1970 and 2000 (predicted). It is the changes and trends over this 30 year period that are of significance rather than the proportions in the individual decades. They highlight that

1. Primary data capture as a percentage of total activity has diminished and is expected to occupy only about 10% of the total by the year 2000. Future data capture will be focussed on updating, upgrading and refining the base data sets.

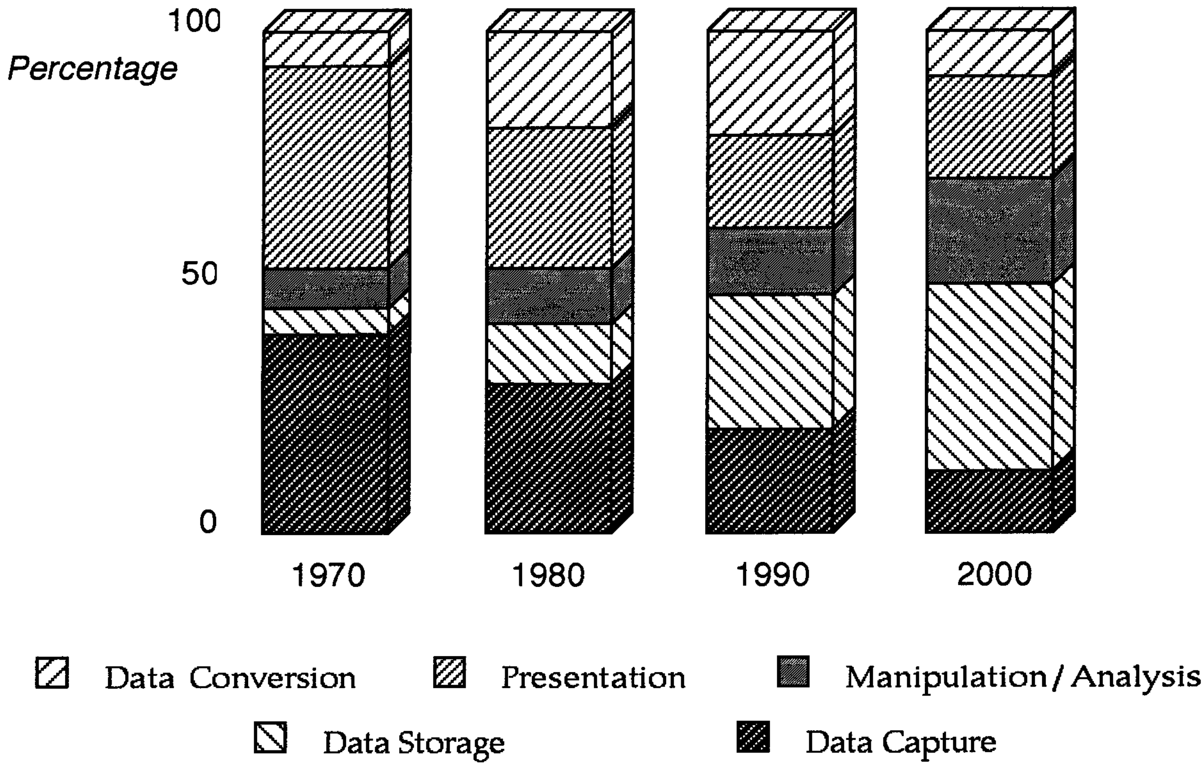

Figure 1: Relativities of LIM functions 1970-2000

2. The storage and management of the collected data, from being a relatively insignificant activity in 1970, is expected to become the single largest activity by the year 2000. Even though data capture effort will be proportionately small, data volumes are predicted to continue increasing through analysis and value added activities on the core information.

3. With the availability of mature digital data, data manipulation, analysis and modelling activities can be expected to increase.

4. Traditionally, most land related information was presented in a form of paper maps. As users acquire their own computer mapping / thematic / graphic capabilities, users will tend to acquire more "raw" data than in the past. Relative to other LIM

activities, the data presentation component is expected to decline to a steady 20% of the total by the year 2000.

5. Analog to digital conversion (computerisation) in the spatial and textual domains, is due to peak about now and decline rapidly in importance in future years.

Trends in project, as distinct from programme activities, are not as clear, but are not expected to be markedly different.

The implication of these trends for education and training in LIM are clear. As Sedunary [1991] notes

> "Our needs grew out of an emerging realisation that, in the future, the principal business of the department - that upon which our continued existence will depend - will *not* be the traditional surveying, mapping, land titling, valuation or whatever, but *the utilisation of our data asset.* The other functions will play a supporting role to that principal business."

The management, manipulation and communication of digital land information are likely to occupy about two-thirds of the total LIM effort by the year 2000. Syllabi and courses should therefore include these activities at their core - their *raison d'être* - with the traditional technique based topics associated with data capture and display on the fringes.

As the AURISA Report on Education and Research in LIS/GIS indicates [AURISA 1988], there were no undergraduate courses with such an emphasis on offer up to 1987. A number of LIM post-graduate diplomas offered in Australia, however, are beginning to take on this data management emphasis.

User environment

GIS/LIS is a ubiquitous, enabling technology that has utility for most economic and social planning and operational tasks. Within its "traditional" landed sciences arena, GIS/LIS technology is now being applied widely [Figure 2]. From its origins in the systems planning movement in the 1970's and the land records improvement programmes of the early 1980's, it has spread into the natural resources, municipal and mapping arenas. The total number of licences on issue in this group in Australia is estimated to be about 600, with all but a handful being installed during the last decade.

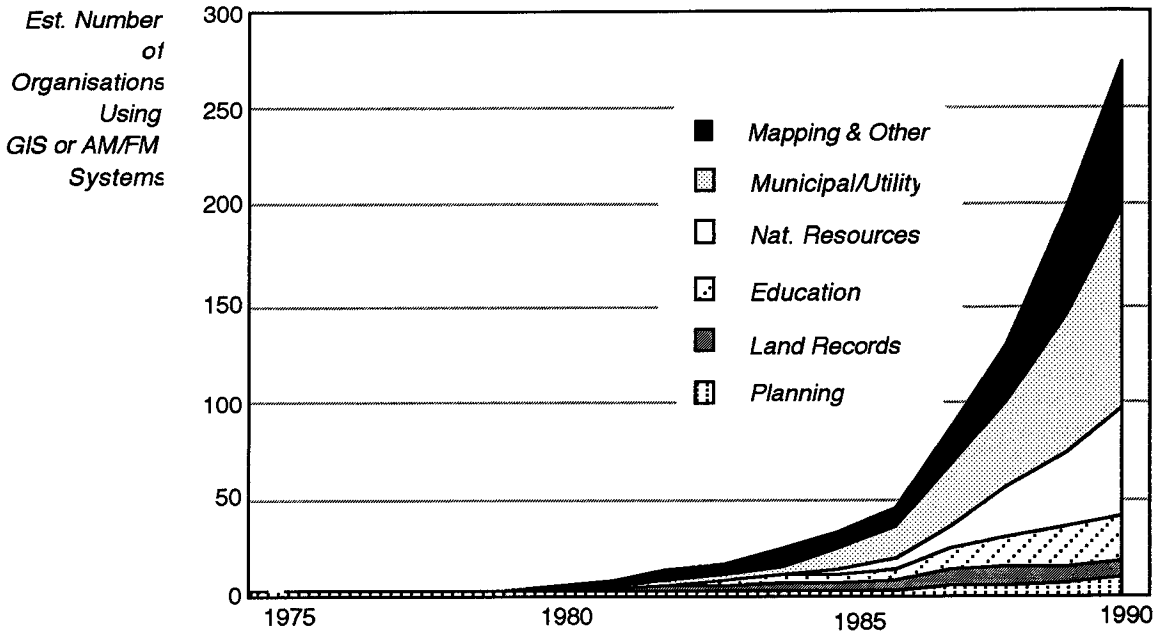

Figure 2: Estimated GIS Growth in Australia 1975-1990
(Estimates Based on Figures Supplied by Selected Software Vendors in Australia)

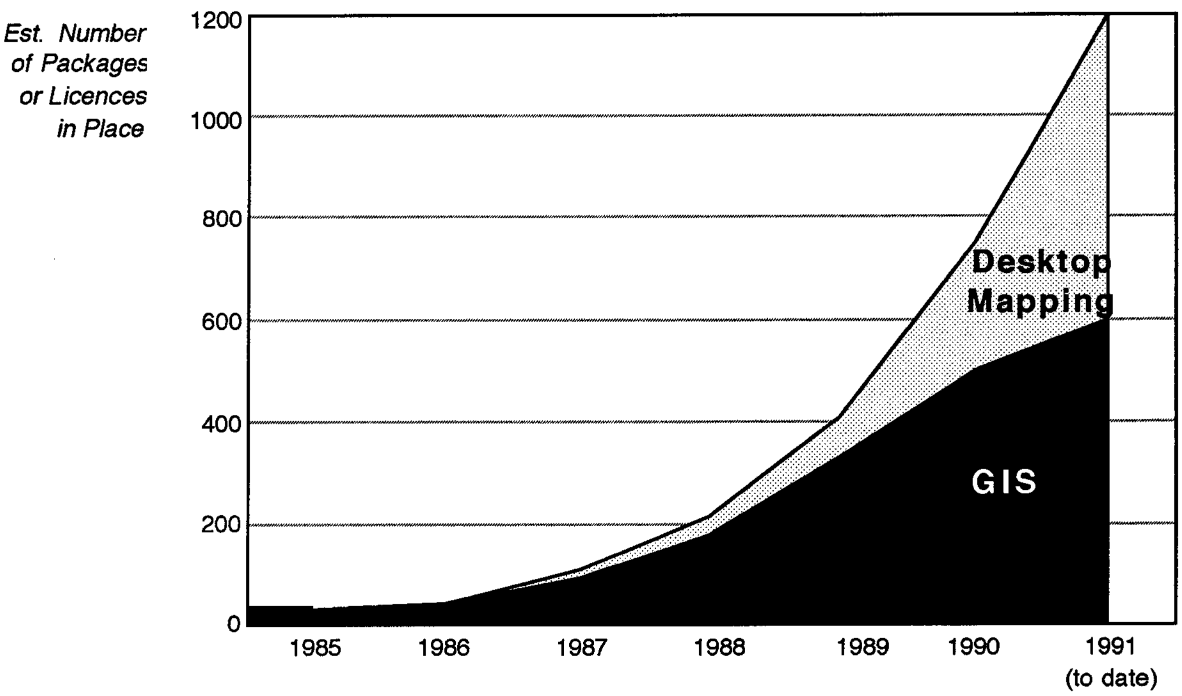

Figure 3: GIS and Desktop Mapping In Australia 1985-1991
(Estimates Based on Figures Supplied by Selected Software Vendors in Australia)

Even more spectacular has been the take-up by the wider non-land based community, i.e. the desktop mapping - the mass market of Figure 3. It has been swift and dramatic, fully supporting the Daratech [1988] statement that "the nature of the market for GIS is about to change dramatically as social and technological developments accelerate and more and more organisations in private industry become aware that GIS can help them understand and manage their business information more effectively". The total installed base of the desk-top mapping systems - of perhaps limited analysis capabilities but with easy to use mapping and display options - is now equal to, and growing considerably faster than the systems used in the land based disciplines. There appear to be two principal reasons for this growth.

1. The availability of low cost, easy to use, easy to learn PC based mapping software - as distinct from CAD - with pseudo GIS functionality and excellent mapping / graphic functions linked to standard PC database packages.

2. The availability of mature data sets in standard formats at commercial acceptable prices and conditions.

The functionality of these PC based packages is being continually upgraded as is the availability of data. It is difficult to forecast with any degree of certainty the size of this mass market. Suffice it to say that for the purposes of this discussion it will be significantly larger and more diverse than the land based systems.

GIS and the LIM function have become truly multi-disciplinary tools of wide utility and applicability for operational and planning tasks in large sections of the community. These trends have a number of repercussions for LIM education and training.

EDUCATION AND TRAINING IMPLICATIONS

Course design

Even without the mass market developments, land information management practices will need to be introduced into environments as diverse as forest management and infrastructure monitoring in local councils [Figure 2]. People educated in the core LIM activities, supplemented by application specific training and experience, will be required to effectively manage each of these information resources. A good example of a training course to meet such a need is the in house course by the South Australian Lands Department LIM [Table 1]. A more general course structure would separate the topics into core (perhaps the **bold** topics in Table 1) and application specific components, with the latter tailored for each application area.

	Module	Topic
1.	Introduction	The program; the department of lands; the need for effective LIM; the management framework
2.	Historical Development of the State	Colonisation and settlement; survey and mapping; land registration; cadastral concepts
3.	**Survey**	Map projections and co-ord. systems; geodetic networks; principles of surveying and control; surveying techniques; automated systems
4.	**Mapping**	Map types; techniques of map production; photogrammetry and remote sensing; digital mapping
5.	Land Registration	Forms of tenure, ownership; easements and restrictions; incumbrances; conveyancing and registration process; automated systems
6.	Land Division	Planning process; surveying; registration; mapping
7.	Land Valuation (Fiscal cadastre)	Fiscal parcel; purpose of fiscal cadastre; property valuation principles; property valuation techniques; revenue collection; automated systems
8.	**Land Resource Management**	Management of the crown estate; management of government policy; natural resource management; automated systems
9.	**L.I.S. Concepts and Their Evolution**	Philosophy; international; national; state; departmental
10.	**Data Administration**	Philosophy, issues etc.; linkages, parcel identification; commercialisation; data administration tools
11.	**ADP Appreciation**	Hardware; software; networking; data bases; electronic data management
12.	**Systems Analysis and Design**	System development process; cost/benefit justification; project scheduling; task definition; report writing and presentation skills
13.	**Supplementary Topics**	Marketing and client services

Table 1: Course Outline - South Australian Department of Lands LIM Course [Sedunary 1991]

The application component of the syllabi will need to be broad indeed if they are to include the social impact analysis area focussed upon by the mass market - health, welfare, education, transportation, and communication planning and investment. If these areas are to use GIS technology and land related information effectively, efficiently and wisely, some formal training in the technology, use and worth of the data will be necessary. Flexible courses catering for a diverse group of people in a wide range of disparate applications would therefore appear to be required by the user community.

Presentation methods

Preparing and delivering courses to meet this wider community need presents a number of difficulties.

Firstly, information management and GIS technology are enabling rather than stand-alone disciplines, making it unlikely that the breadth of knowledge and experience to span all likely application areas will be found in one department or academic unit. Co-operative, across-faculty and across-discipline courses and teaching patterns offer the most promising solution. Institutional reforms designed to encourage such co-operation, like the Centre for Spatial Information Studies at the University of Tasmania - a deliberate effort to make GIS/LIM a university wide rather than just a Surveying effort - should lead to a more focussed and orderly diffusion of the technology and practice within a university or college.

Secondly, the community will need people with a range of LIM skills. A detailed study completed in Western Australian concluded that LIS/GIS training was required at three levels: management, supervisory, and operational, each with its own course, emphasis and presentation (delivery) methods [WALIS 1988]. As well, the study identified the training needs for end-users of the system, both at the corporate and data systems levels. The study confirmed that most LIS/GIS courses on offer today have a technological bias directed at the operational and supervisory levels. Few, if any, courses cater for the needs of management or the end-user who is merely interested in applying the data and technology without a detailed or theoretical knowledge of either.

The education and training needs of management and end-users, however, pose a number of problems. As Table 2 indicates, the present technologically oriented courses are designed to instruct closed, well-defined groups with well-defined goals, often on a formal basis. Managers and end-users, on the other hand, are much more heterogeneous, requiring course structures and content amenable to individual differences in terms of prerequisites and objectives. The contents of such courses, their context as well as their presentation, will therefore need to be quite different from existing courses. One method of designing and teaching courses of this type is

	LIM Technologists	End-Users
Educational background	uniform	disparate
Type of knowledge required	technical	applications
Level of knowledge required	detailed	conceptual/operational
Amount of knowledge required	comprehensive	focussed
Course goals	uniform	varied
Course times	regular	ad hoc
Course participation	group	individual

Table 2: Comparison of Education Profiles Technologists - End-Users [Zwart 1990]

explored by Zwart [1990].

SUMMARY

The foregoing discussion infers that the complete range of LIM activities, from data capture to data management are within the scope of the Land Information Manager. It, in turn, rests on the corporate information resource / IRM ideal. A number of factors, however, are likely to detract from this ideal. The first of these is that future land information managers will probably have little control, save in an advisory capacity on how their information may be used. End users, other than central operatives, will increasingly perform the analysis and modelling functions on their own terminals or desktop systems. Much of the resultant information is unlikely to become part of the corporate data resource. It must be asked, therefore, whether the manipulation and analysis of data depicted in Figure 1 should be the responsibility of the land information manager, or the application specialist. Also, where, by whom, and within which context, should these skills be taught.

Similarly, social and economic applications of certain types of land information in combination with other statistical data is set to become a highly significant . How these applications, the techniques they employ, and the results they produce fit in the LIM philosophy is unclear. Until issues of this kind are clarified (if ever) LIM courses, their syllabi and delivery methods must remain open, flexible, and sensitive to user needs for training and education. This will entail, amongst other things,

1. A recognition that management and protection of the integrity of the information resource is the core activity; consequently this should form the rationale and focus for courses of instruction. Other activities such as data collection and presentation should be taught from this perspective.

2. A reflection in the LIM syllabi and course emphasis of the changing relativities amongst the component activities in land information management. Greater weight will therefore have to be given in future years to data storage and data manipulation at the expense of collection and conversion.

3. An acceptance that LIM is not a unitary function, but dependent on the land information systems stage of maturity, its purpose, operational context and user community.

4. An explicit acknowledgement that LIM will be practised in a wide range of organisations and professions. Hence, a multi-disciplinary approach to teaching and training LIM involving at its core management, information science and surveying expertise, but focussing on its role in some designated discipline, e.g. mining, forestry, urban planning, transportation, marketing.

5. Offer courses to meet the needs of a number of types of LIS/GIS users, from the technical expert managing the systems database, to the novice GIS illiterate end user - from management to technician, from system designer to system user.

6. Unconventional methods of course delivery at non-standard times will need to be explored if education and training needs are to be satisfied.

7. A recognition that land information will be used as a basis for a range of social, economic, and administrative planning and operational functions. These wider applications will also need to be covered in the courses.

CONCLUSION

The task to be performed by the Land Information Manager to maintain and service their information resource are changing as are the demands placed on this resource by users. In addition, the geographic information systems underpinning the resource are becoming more affordable and applicable to a larger and more diverse groups of users. As a consequence, the LIM function will be performed in a wide range of organisations, by people with varied backgrounds and experience attempting to achieve a variety of goals.

To meet the education and training challenge this dynamic environment presents, the paper makes a number of suggestions about the characteristics, design and presentation methods. While it takes the view that at least, in the short term, LIM education will be through co-operative efforts between relevant disciplines, there is little doubt that multiple, highly specialised LIM training options taught by a number of disciplines will emerge as the technology and the need to manage systems spreads through the community.

The demand for education in LIM, as the WA survey indicates, is large and growing. Given the dynamics of the technology and its application, responding in a meaningful and pertinent manner will not be easy. It is only those courses which are sensitive to user needs, that can adapt to changing environments, and are flexible in their offerings that are likely to have any place in LIM education and training in the future.

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