Northern Territory (Australia) Spatial Data Infrastructure – Now and Beyond

Phillip RUDD and Robert SARIB, Australia

Key words: Digital cadastre, Land management, GSDI.

SUMMARY

The Department of Infrastructure, Planning and Environment was created in 2001 as the lead land management, land development and land information agency in the Northern Territory. The Department now comprises most of the land, water and environmental management-related functions carried out by the Northern Territory Government. Land and Geographical (spatial) Information is critical to promote economic and social development, improve management of our natural resources and protect the environment. It is in these latter two fields that there has been a great deal of activity at the National and State levels in recent times.

The road towards a homogenous spatial data infrastructure for the Northern Territory has had some detours and pot holes needing innovative thinking along the way. The geodetic framework has been moved to a geocentric datum, the spatial accuracy of the digital cadastral framework has been upgraded to be survey accurate, a sophisticated web-based land administration system has been implemented which also allows user defined integration of over 200 spatial data themes. All of these components are integral to the Northern Territory's Spatial Data Infrastructure and have enabled the spatial data user to capitalise on the benefits of a homogenous and seamless land management environment.

This paper outlines the strategies adopted in the Northern Territory to get its own corporate spatial data into order so that it is in a position to effectively contribute to national and international initiatives for spatial data infrastructures, directories and atlases.

Northern Territory (Australia) Spatial Data Infrastructure – Now and Beyond

Phillip RUDD and Robert SARIB, Australia

1. INTRODUCTION

In the same way that governments in the past have developed transport, telecommunications, health and education infrastructures it is argued that a nationally consistent Spatial Data Infrastructure (SDI) is essential if Australia is to manage, and hopefully resolve, all manner of land administration reform and other natural resource management issues that it is facing.

It has been generally accepted that, if the Northern Territory (NT) is to reap the benefits of its investment in its SDI, then land information must be readily accessible by decision makers and the community. This approach is consistent with NT Government's commitment to ensuring that the NT captures the benefits of the information technology industry and its vision of establishing the Territory as a leading edge user of on-line technology.

The Department of Infrastructure, Planning and Environment (DIPE) is the lead agency responsible for ensuring the NT maximises available economies of scale in developing geographic information systems and to ensure that all agencies involved in geographic information systems will be able to communicate directly with each other. This role stems from recognition that much of what the NT Government wants to do in the land development, natural resource management and environment protection fields can only be achieved with high quality, consistent spatial information. It also recognises that there are high costs involved in establishing and maintaining the large amounts of common information required by the many different government agencies involved in these activities.

DIPE depends on computer based information resources and applications for most of its operations, primarily relating to:-

1. corporate land and water information data bases and applications that are part of the NT Land Information System (NTLIS);
2. a variety of GIS data sets and applications; and
3. corporate business and office automation applications.

Information resources managed and delivered through the NTLIS program support the operations of many other NT Government agencies and the private sector. Specific applications, such as the Land Titles System, Town Planning System and Computer Assisted Valuation System, are critical to government operations supporting land development and land management.

The NTLIS program is also responsible for coordinating, monitoring and advising agencies on Geographic Information Systems (GIS) and associated spatial data management activities and has established corporate licensing of a number of GIS products.

2. THE NORTHERN TERRITORY SPATIAL DATA INFRASTRUCTURE (NTSDI)

The NT Government has implemented a SDI model that has the following core components:-

– **An Institutional Framework** - which can be regarded as the cooperative arrangements between data providers and users and through which policies and administrative arrangements can be defined for building, maintaining, accessing and applying standards to the data sets.
– **Technical Standards** - which define the technical characteristics of the data sets.
– **Data Sets** - which are produced within the institutional framework and fully comply with the agreed standards.
– **An Access Network** - that provides the means by which data sets are made available to the community.
– **NTLIS Architectures –** the agreed data, application and technology architectures that provide a framework for consistent whole of government data management, application development and delivery of land and natural resources related data and products for decision making.

In practice, the NTSDI consists of a distributed network of databases linked by common standards and protocols to ensure consistency and compatibility, each managed by Custodians committed to agreed data management principles. Key factors in the success of the NTSDI are the strategy to focus on corporate data and applications, the non-duplication of data and the enforcement of data and application standards throughout the NT Government. The information management principles of data custodianship and its once-only capture and maintenance have been consistently applied, as has the use of "open" standards based applications and spatial metadata to agreed standards.

2.1 Institutional Framework

The key element of the NT's governance of its SDI is a Cabinet endorsed policy framework and a set of guidelines that covers:-

– Custodianship of Corporate Land Information;
– Access to Corporate Land Information;
– Information about Spatial Data or Metadata;
– Commercial Supply of Data;
– Data Supply and Licensing Agreements;
– Management of Copyright and Intellectual Property; and
– Management of Liability.

2.1.1 Custodianship

Custodians do not "own" data but hold it in trusteeship on behalf of the community and are accountable for the integrity of the data in their care. The criteria used for selecting an agency as a Custodian for Corporate land information and spatial data sets in the NTSDI are that the agency:-

- has sole statutory responsibility for the capture and maintenance of the data;
- has the greatest operational need for the data;
- is the first to record changes to the data;
- is the most competent to capture and/or maintain the data;
- is in the best economic position to justify collection of the data at source; or
- requires the highest integrity of the data.

In the context of the NTSDI, "Corporate land information" is defined as the spatial, geographic and attribute information required by two or more government agencies or industry organisations to carry out their core business functions.

When accepting Custodianship, an agency needs to take into account the responsibilities that this entails and whether it can meet the requirements adequately. Custodians are also responsible for establishing the marketing conditions for their Corporate land information within the access policy framework established by the NT Government and include the terms and conditions under which data may be used for value-added information products.

A full description of a Custodian's responsibilities in the NTSDI can be found on this web page:- http://www.ntlis.nt.gov.au/NTSDI/d308-custodianGuide.htm .

2.1.2 Access Policy

The NT's Access Policy is based on the belief that the NT is best served by data management and access policies that encourage and facilitate the use and integration of data. For instance, the price of data and access should not be an impediment to the use of data. Prices for Corporate land information should be set at the lowest level that encourages its efficient and effective use, avoids duplication and overlap in collection and maintenance of data, and promotes data integration.

The NT Government has set the following policies for the Custodians to follow when fulfilling their responsibility to make their Corporate land information accessible to others:-

- Corporate land information and data are collected and managed on behalf of the community and NT Government agencies will adopt procedures designed to maximise access to and use of it by all sectors of the community;
- Access to non-confidential Corporate land information and data between NT Government agencies will be either at no cost to the accessing agency or at a charge limited to the cost of providing access and converting the information to the form requested by the accessing agency; and
- Access to non-confidential Corporate land information and data by non-NT Government agencies and organisations will be on terms and conditions that balance the benefits of access with protection of the community's interests.

This policy has encouraged the Custodians to utilise web technologies as a means of minimising their cost and resources to make their Corporate land information widely accessible. The policy has also encouraged the agencies accessing the Corporate land information from the NTSDI to adopt standards to minimise their cost and effort to integrate the relevant Corporate land information into their business operations.

2.1.3 Metadata

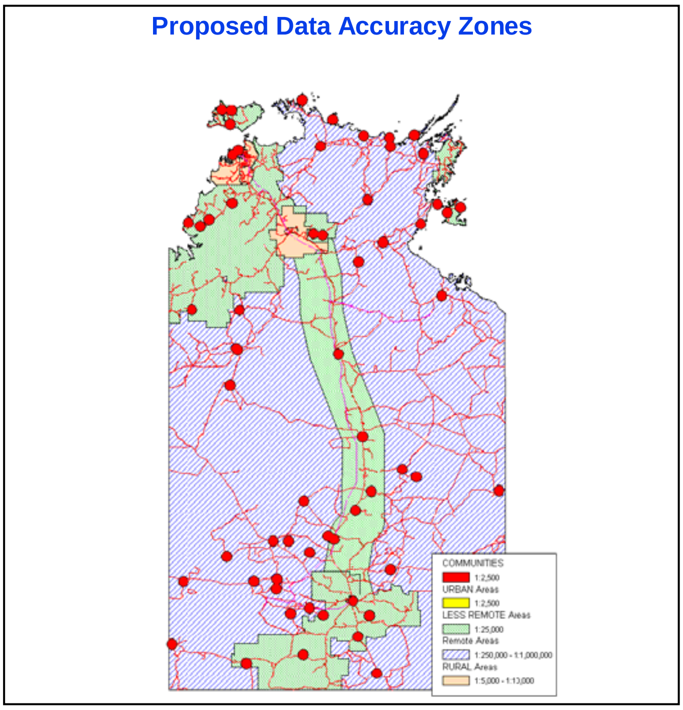
Custodians have a responsibility to provide a description (ie metadata) for their Corporate land information and other spatial data sets to the NT Spatial Data Directory (NTSDD). These metadata records must conform to the agreed metadata standard. The NTSDI has implemented the national metadata profile for spatial data implemented, which was developed by the Australian New Zealand Land Information Council (ANZLIC) to define the minimum number of attributes (ie Level 0) that should be stored for each spatial data set. The NT Government has added Level 1 attributes to provide for additional local functionality to manage its spatial data.

ANZLIC is currently coordinating work to migrate this Australasian metadata standard to an implementation of the International Standards Organisation's (ISO) metadata standard ISO19115 as described on their website at:
http://www.anzlic.org.au/infrastructure_metadata.html.

2.2 Technical Standards for Corporate Land Information

Custodians must develop and apply standards to the data that conform with relevant national, international or otherwise agreed standards. General standards have been adopted, for the spatial referencing base for all NTSDI data (as described in Section 2.3 below). However, Custodians must also define classification standards, wherever possible using national or international standards, and the minimum levels of accuracy, completeness and coverage that should apply to the data sets within the NTSDI.

The NTLIS data working group has proposed that all Corporate land information covering the zones shown in the diagram below should be captured and maintained to the recommended minimum spatial accuracy standard as shown for that zone to improve consistency and usability of the NTSDI's core spatial data sets.



2.3 Data Sets

A core of 64 Corporate spatial, image and attribute data sets, which are listed in Appendix 1, have been defined for the NTSDI. The NT's fundamental reference layer for spatial data infrastructure consists of the geodetic network as recorded in the Northern Territory Geodetic Survey System (NTGeSS) and the Digital Cadastral Data Base (DCDB). Both are based on a geocentric datum known as Geocentric Datum of Australia (GDA) 94.

GDA94 is defined by: -

Reference Frame	ITRF92 (International Terrestrial Reference Frame 1992)
Epoch	1994.0
Ellipsoid	GRS80
Semi-major axis (a)	6,378,137.0 metres
Inverse flattening (1/f)	298.257222101

The NT vertical datum (since 1971) is the Australian Height Datum (AHD) and is based on the surface "which passes through mean sea level at the thirty tide gauges and through points at zero AHD height vertically below the other basic junction points." (ICSM, 2001).

DIPE is directly responsible for the maintenance of the following 18 core spatial data sets and it is the custodian for 15 of them:-

Custodian - DIPE		
Geodetic Infrastructure	Place Names	Topographic data and mapping
Survey measurements and plans	NT component of Geocoded National address File (G-NAF)	Aerial Photography and Satellite Imagery Library
Cadastre (DCDB)	Places of Interest (2005)	Roads Network
Land Valuations	Aboriginal Communities	Flood Mapping
Statutory Land Use Plans	Native Title and Land Claims	Storm Surge mapping
Data sets maintained for other Custodians		
Administrative Boundaries	Electoral Boundaries	Remote Communities Infrastructure (SLAP)

2.3.1 NT Geodetic Survey System (NTGeSS)

With respect to NT SDI, the main function of NTGeSS is to provide a foundation for the DCDB's spatial integrity through a geodetic reference frame or co-ordinate system. In 1996 NTLIS adopted GDA94 as the datum and coordinate system to replace the previous Australian Geodetic Datum 1966 (AGD66). Moving to a geocentric datum created a platform for the development of a single standard for collecting, storing and using geographic data. It also enabled:-

– better integration with numerous land and geographic systems at the local, regional, and national level;
– the direct use of global navigation satellite systems such as 'GPS';
– integration and compatibility with other international coordinate sets such as the World Geodetic System 1984 (WGS84);
– the utilisation of the latest surveying techniques; and
– the establishment of a modern and accessible positioning framework free of distortion for most practical purposes.

To facilitate the transformation of the NT's existing geodetic network to the new reference system, major GPS and terrestrial surveys/campaigns at the local, state, national and global levels were performed. Both the private and public sectors of the survey industry were mobilised to undertake the following campaigns:–

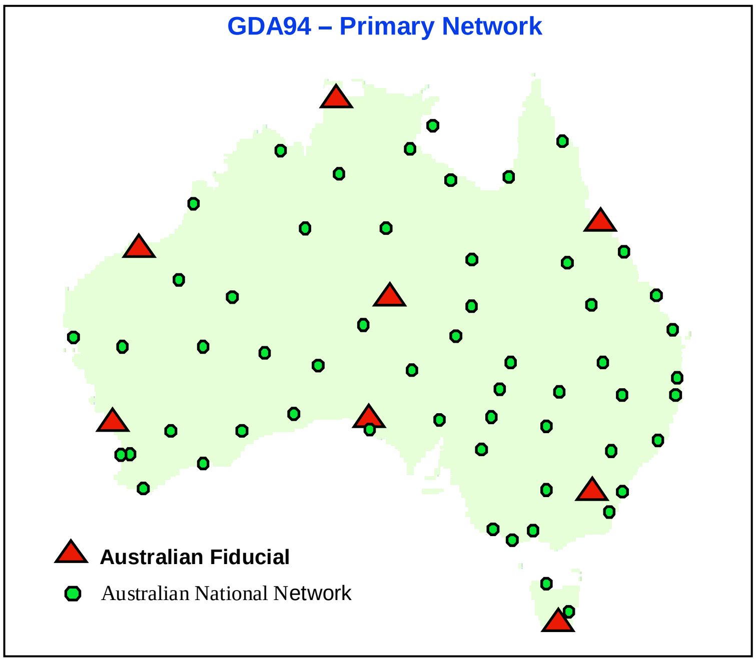
1992 – GPS survey of 8 geologically stable marks known as the Australian Fiducial Network (AFN) which are also part of the world-wide International GPS Service (IGS) network.

1992 to 1994 – GPS survey of 70 locations across Australia to create the Australian National Network (ANN).

1994 to 2005 – GPS and terrestrial surveys throughout the Northern Territory to upgrade the existing Territory Geodetic Network (TGN) and to establish the 'street' or 'corner' level framework known as the Co-ordinated Reference Mark (CRM) network.

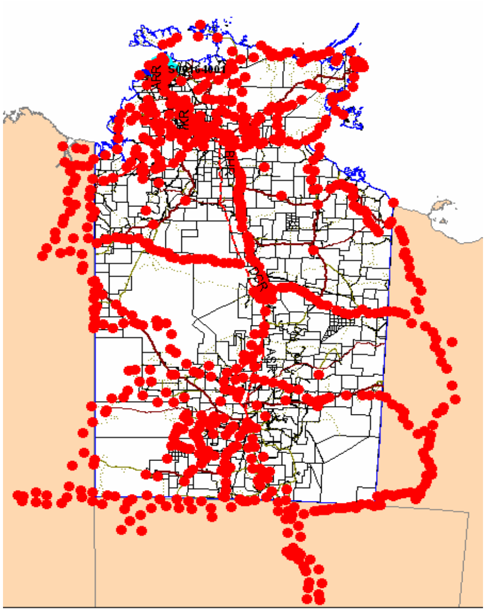
As result of these various surveys, a hierarchical control network structure for NTGeSS was established consisting of:–

– **The Primary Network** - encompassing the Australian Fiducial Network (AFN) and Australian National Network (ANN). It consists of approximately 80 marks spread over the Australian continent at a nominal spacing of 500 km;



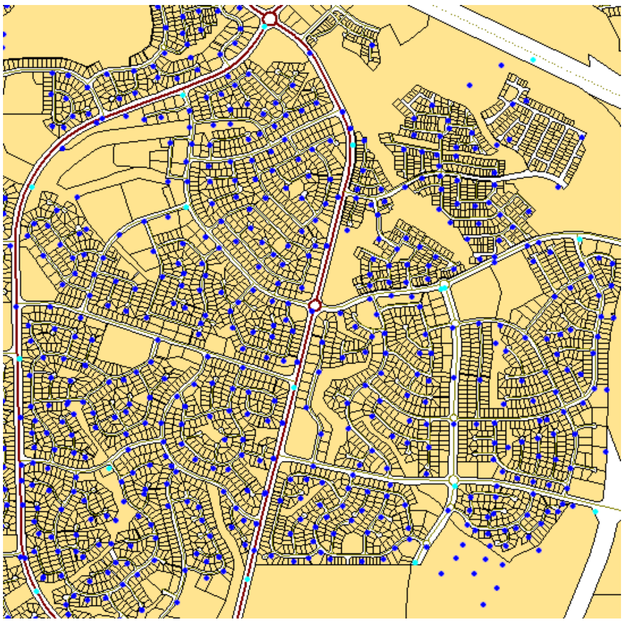
– **The Secondary Network** - known as the Territory Geodetic Network (TGN). This network consists of approximately 1000 marks at a density ranging from 10 km to 500 km, and usually positioned along major infrastructure routes such as roads or service corridors; and

GDA94 – Territory Geodetic Network (TGN)



– **The Tertiary Network** – consists of approximately 20,000 Coordinated Reference Marks (CRMs) and coordinated cadastral marks. The nominal extents of the CRM networks are defined by discrete geographical areas bounded by such things as natural boundaries, major transit corridors or existing administrative land boundaries. The size of the each CRM data set is usually no more than 700 stations/marks with the marks positioned at a density varying from 100m to 50 km apart.

GDA94 – Coordinated Reference Marks (CRM)



All the survey control marks in NTGeSS were surveyed and adjusted in accordance with the standards and practices for survey control published by the Intergovernmental Committee on Surveying and Mapping's[1]. The 'whole to the part' methodology was employed where each survey control network was fixed or constrained by control from a higher order 'parent' data set during the least squares adjustment process. The primary rigorous least squares application used to adjust all geodetic networks was Newgan[2].

2.3.2 Digital Cadastral Data Base (DCDB)

The digital record of NT's cadastral coordinates and boundary information is maintained in the DCDB. The primary roles of this database are to 'underpin' corporate spatial data sets and to provide a graphic record or index of the land parcel and cadastral framework.

The NT's DCDB was first established in 1983 when emerging information technology for the mainframe enabled the spatial component of data to be linked to the textual land information. At that time, the principal methodology employed to capture and geo-reference the data was tablet digitisation of the best cadastral maps available. These maps varied from 1:2,500 scale maps of urban locations to 1:500,000 scale "sketch maps" of the rural and pastoral areas. As a consequence of using this source data, the DCDB at that time had a positional uncertainty ranging from ±5 metres in urban areas to ±10's of metres in rural areas and ±100s's of metres in pastoral areas.

During the late 1980's and early 1990's, the accuracy of the DCDB could satisfy most spatial users whose requirements were to display textual information on a cadastral base map or as a graphical index into various databases held in the land information systems. With the advent of satellite navigation systems such as GPS, the closer integration of land and geographical information systems, advances in specialised computing applications and users with spatial data of high integrity, many users were now demanding a commensurate level of accuracy and integrity in the DCDB and that it be supplied in a format that they could use with their GIS software running on their desktop computer.

In 1996 the DCDB was transformed to a seamless data set based on GDA94 geographical coordinates (ie latitude and longitude). Although this was an achievement in itself, the data was migrated at the same level of accuracy as the original 1986 data set. Since then the improvement of the spatial accuracy of the DCDB has been done stages.

2.4 Access to Corporate Land Information

A primary objective of the NTLIS is to make it easier, faster and cheaper for the community, industry and all levels of government to access non-confidential Corporate land information in the belief that it is essential for good decision making. The two main NTLIS applications that are focused on this objective for the delivery and the sustainable management and

[1] Refer to website http://www.icsm.gov.au/icsm/publications/sp1/sp1.htm
[2] Newgan is the rigorous least squares geodetic adjustment package developed by Dr. J S Allman.

maintenance of Corporate spatial data and land information are the Integrated Land Information System (ILIS) and ILIS Maps.

2.4.1 ILIS – The Integrated Land Information System

ILIS is the result of a two year redevelopment of the previous 21 year old mainframe based Land Administration Information System. It is primarily a web standards based real time system that uses a web browser and modern internet technologies to link all known, or at least accessible, data associated with a parcel of land.

ILIS is a suite of integrated business process modules utilising eXtensible Markup Language (XML) to represent the data content of a transaction independently from its presentation to capture and maintain administrative data on all parcels of land or other defined and uniquely identified polygons. These parcels of land do not have to be identified by survey, but can be allocated numbers for administrative purposes only. Data can also be recorded at the sub-parcel level (eg. unit titles) and cross-referencing enables recording of data for multi-parcel properties.

All the attribute data held in ILIS is created and maintained as part of administrative and business processes with a full temporal history of the data being maintained. In most instances ILIS ***is*** the administrative process and staff cannot complete their work without using their particular ILIS business module. The following business functions are provided by ILIS:-

- Land titles registration (where the ILIS electronic record is the legal "title document");
- Cadastral survey records and coordinates;
- Statutory valuation;
- Computer assisted valuation;
- Crown land and lease management, including pastoral leases;
- Statutory planning and development control;
- Statutory building control;
- Sale and release of NT Government land and property;
- Land acquisition for NT Government use;
- NT Government land asset management and reporting for accrual accounting;
- Recording of land use and administrative interests; and
- Management Reporting.

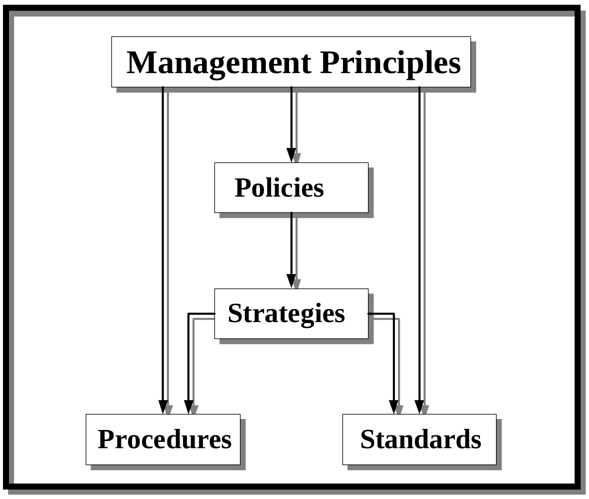
In addition to the primary parcel key, access to data is by owner name, street address, title reference, tenure reference, property name and administrative file number. By interfacing specific ILIS applications to office automation platforms and web services, the full text of documents is captured for display (eg. Planning Instruments).

2.4.2 ILIS Maps

The ILIS Maps application provides a spatial index for many of the NTLIS data sets. It also provides a framework for visualising the spatial relationships between data sets in the spatial domain and then linking to the systems that maintain further information about the spatial object.

2.5 NTLIS Architectures

These architectures are based on data management principles that are becoming common across industry sectors and which provide the information management framework for development of policies, strategies, standards and procedures as illustrated in the diagram below.



The NTLIS Architectures have been designed to provide a framework for agencies to achieve the following objectives that they have adopted and have been endorsed by Cabinet as the targets to be achieved through effective coordination of land information management and the NTSDI:-

- all agencies commit to a common strategic direction;
- corporate data and information is easily accessible and usable across agencies and by external users in the private sector and the NT community;
- agencies retain and recognise their responsibility for effective management of the information for which they are Custodians.

  duplication of data and development effort is eliminated to minimise the costs of development and support of the NTSDI;
- agencies have access to good technical advice and user support for their Corporate land information systems and GIS;
- involvement of the private sector in developing and managing LIS/GIS is increased;
- partnerships are developed with the private sector as a means of strengthening the Territory's land information industry; and

– a whole of NT Government view is provided to ANZLIC and other national coordination groups;

The NTLIS technical architecture, which was designed and endorsed in 2001, takes into account the following target characteristics of the NT Government's Corporate land information and spatial data management environment:-

– All Corporate land information and, where relevant, the source data from which it is derived should be managed using industry standard SQL compliant relational database software;
– The database software should natively support spatial functions for spatial features. Alternatively, an "open" spatial data manager product must exist between the metadata and application layers;
– Spatial data and metadata should be stored in a database rather than the application layers or in application specific file formats;
– All metadata and application layers should be based on access and maintenance of data by way of web technologies and standards (eg from the Open GIS Consortium, the World Wide Web Consortium and the International Standards Organisation);
– To minimise overheads in accessing data, a layer of predefined spatial objects accompanied by attributes and feature level metadata is required;
– Business applications may be custom built or commercial packages, but they should both be based on industry standards;
– A range of end user application (client) products should be defined according to functional requirements. These products should have the capability to interface to any and all of the other architecture layers to access and maintain data. They must not be used to store and manage corporate data sets or products in application specific formats;
– The architecture incorporates standard Intranet and Internet Web access mechanisms so that secure data access can be provided directly to the business application, distributed spatial object, application server and metadata/query interface layers.
– The architecture should not assume a centralised NT Government computing environment – ie databases may be distributed or multi-organisational, while distributed objects/services may be private sector value added products.

2.6 Resources

To put the following analysis into perspective the NT comprises of 53 500 current parcels and covers approximately 1.35million km^2, which is 17.5% of Australia's land mass. The Land Information Division has a total of 34 personnel that are involved in the maintenance of the NTLIS with a combined annual salaries and operational budget of AUD4.4 million. This amount, like other agencies that maintain NTLIS corporate data sets, is not solely used for the maintenance of the NTSDI or the cadastral and geodetic framework, but also includes expenditure on major projects, maintenance of systems/processes and the costs associated with normal government agency operations.

To date the NT Government has spent AUD10.5 million on the development of the spatial accuracy upgrade and coordinated cadastre project over the last ten years. It is estimated another AUD2.5 million is required to complete the project. In terms of price per parcel it has cost the NT Government approximately AUD243 per parcel to achieve a survey accurate cadastre.

Since ILIS went into production following a AUD2 million migration of the old mainframe system over three years, it is now costing approximately AUD1.3 million per year to maintain and enhance the functionality of the administrative functions in ILIS and ILIS Maps. In terms of a per parcel cost to the NT Government, this represents an on-going commitment of approximately AUD24.30 per parcel per year which is expected to decrease to about AUD22.00 per parcel per year when the phase 2 development is completed at the end of 2005.

3. FUTURE DEVELOPMENTS AND CHALLENGES

3.1 Geodetic and Cadastral Control Network

Today, the geodetic and cadastral control network is progressing steadily towards a dynamic environment of interrelated knowledge and expertise, horizontal and vertical survey control data, policies, procedures, standards and spatial information technology. The densification and reformation of the NT geodetic and cadastral control network , has served three primary functions:-

1. As the fundamental reference layers for NT spatial data infrastructure ,
2. As the reference frame for a NT co-ordinated cadastre and subsequently the catalyst to cadastral / land administrative reform, and
3. As the main positional infrastructure for the surveyor or spatial scientist to use in their day-to-day business operations.

To date, most of the urban areas in the NT have established CRM networks to centimetre accuracy, and co-ordinated parcels with a relative positional uncertainty of 0.1 m or better (at the one sigma level). In the pastoral and rural areas 75 % of the parcels have been coordinated to a relative positional uncertainty of 1.0 m or better (at the one sigma level) with CRMs and co-ordinated cadastral marks distributed over these regions at a density ranging from 2 km to 50 km.

Resolution of geodetic and cadastral data management issues have been the main business outcomes for the last few years, and it is expected that future maintenance of such will require constant monitoring, reviewing and modifications. Development of applications for the management of data in a digital environment/system, migration of data, creation of policies and guidelines for file structures, storage platforms, operational processes and protocols are examples of the issues that have been dealt with. It is expected the administrative system for management of both geodetic and cadastral data will be in full production by July 2005. The two systems are:-

- the NTGeSS administrative interface[3] which utilises Oracle database technology and manages all geodetic data in tree directory structure; and
- SPICAD[4] which also uses Oracle database technology and manages the cadastral co-ordinates, the survey geometry and parcel data in a seamless environment.

A future challenge for the geodetic and cadastral reference layer in the NTSDI is to establish a continuous on-line reference system (CORS) based on global navigation satellite systems (GNSS). It is envisaged this system will assist the maintenance of land information infrastructure, especially the geodetic and cadastral framework, and also provide the spatial user with another mechanism or option for capturing and maintaining their spatial data to the required accuracy level.

3.2 Cadastral data

The main challenge in the future for the DCDB is the selection of an application which can replace the existing corporate data manipulation tool CFM (Cadastral Fabric Manager). The perceived difficulty in this is choosing an application which can effectively and efficiently perform vertical topology[5]. It must also have the capability to conform to the NTLIS architecture for information delivery over the web utilising web services that are integrated with existing business systems.

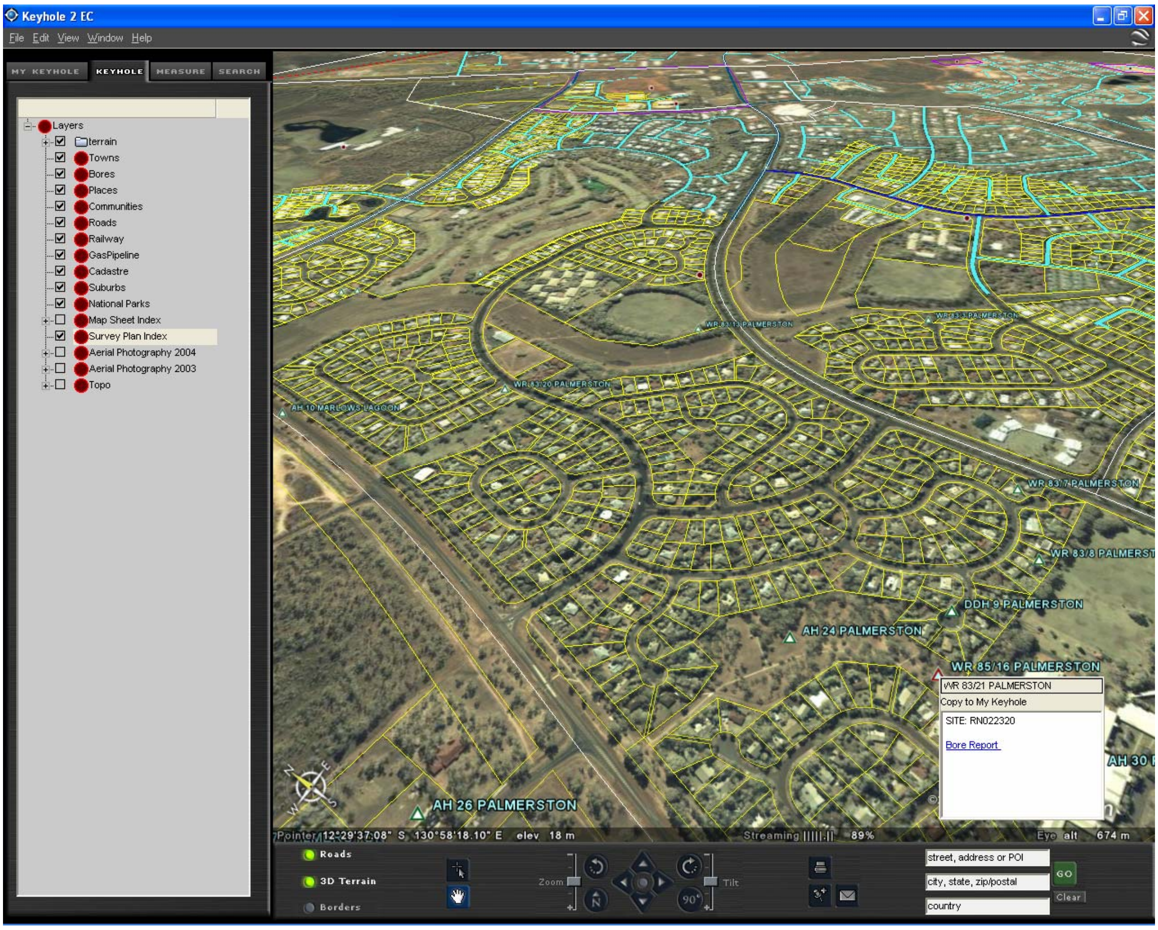
3.3 Visualisation

As spatial data and satellite imagery becomes more accessible to a much broader range of "viewers" and decision makers that are not familiar with the GIS and mapping frameworks and paradigms that the spatial practitioner takes for granted, the challenge is to find an intuitive and interactive interface that this new and rapidly growing audience is comfortable and confident with.

The NTLIS's response to this challenge has been to move away from the "click-and-wait" paradigm for viewing spatial information to a truly interactive, intuitive interface (as shown in the screen image below) that enables a user to break free of the 2 dimensional north/south view of the world currently available through web mapping.

[3] An application developed by Asset Management Systems – Che Diggens.
[4] An application developed by Geodata – Mike Elfick and Mike Fletcher.

[5] Process of re-aligning layers if there has been a change to the reference layer ie the upgrading of cadastral framework.



Technology with its roots in the gaming and web streaming sectors has been implemented to give every user unprecedented levels of information depth while freeing them to roam over a global database of fused vector, image, feature and terrain (3D) information without the costs and distribution issues of traditional methods of distributing spatial data. The client application also has some GIS capabilities, such as spatial searching and measurement, and it facilitates collaboration by sharing annotations and overlays on top of the network resident global database.

4. CONCLUSION

The role of spatial data and information is rapidly extending beyond its traditional applications in mapping, land development and resource management to such areas as emergency management, marketing and health and community services delivery. The challenge for NTLIS is to ensure high quality spatial data is available in a usable form to support both traditional and emerging applications in government, industry, academia and the general community.

The SDI model is being adopted throughout the world as both the end and the means to make available the spatial data required to support a government's economic and community outcomes. In the Northern Territory it has highlighted the fact that the old approach to the use of GIS is no longer tenable.

The development of the NT's survey accurate coordinated cadastre has brought the disciplines of geodesy and cadastral surveying closer together. It has forced the NT land surveyor and the spatial data user to broaden their geodetic knowledge and skills, or to at the very least have a better understanding of coordinate based reference frameworks that underpin the SDI.

Organisations need to ensure that all spatial data are captured in such a manner that it can be effectively managed and maintained as part of a corporate, jurisdictional or national information asset and where necessary, made available to the growing number of users in government, industry and the community. Historic limitations of GIS technology are no longer any excuse to avoid adopting such an approach.

Too often GIS and spatial data management are focused at the project and technical level. Unless strategic outcomes and objectives are clearly defined and the focus maintained on them it can be very difficult to deliver sustainable data management - it is always easier and sometimes cheaper to take short cuts and deliver a project rather than stick to the strategic approach. However, if you take the strategic path to deliver sustainable data management then the potential to deliver more services and practical applications to more people to enable them to deliver their objectives is enormous.

REFERENCES

Department of Industry, Science and Resources (DISR). Sept 2001. *Positioning for Growth – Spatial Information Industry Action Agenda.* Canberra : Commonwealth of Australia.

Department of Lands, Planning & Environment (DLPE). 2001. *ILIS Update*. Darwin : Northern Territory Government .

Department of Lands, Planning & Environment (DLPE). 2001. *NTLIS – NT Metadata Implementation Issues.* Darwin : Northern Territory Government .

Department of Lands, Planning & Environment (DLPE). 2000. *NTLIS – Overview & Architecture.* Darwin : Northern Territory Government

Inter-governmental Committee on Surveying and Mapping. 1997. *Know Where You Stand with GDA*. Canberra : ICSM.

Inter-governmental Committee on Surveying and Mapping. 1999. *Get in Step With the Geocentric Datum*. Canberra : ICSM.

Inter-governmental Committee on Surveying and Mapping. 2002. *GDA Technical Manual.* [online] URL : http://www.icsm.gov.au/icsm/gda/gdatm/index.html [Jan 2005].

Kaufmann, J. & Steudler, D. 1998. "Cadastre 2014 A Vision for the Future". Switzerland : FIG.

Menzies, T.1995. "Northern Territory Cadastral Status Report". *NZ and Australian Cadastral Conference*. Wellington.

Menzies, T. 1998. "The Development of a Co-ordinate Cadastre in the Northern Territory". *Discover Your Future – Reflect on Your Past. 24th National Surveying Conference*. Institute of Engineering and Mining Surveyors (Australia). Alice Springs (October).

Rudd, P. 1999. "Building a Distributed Spatial Infrastructure for Corporate National Resource Data". *Western Australian Land Information Systems Forum.* Perth (February)

Rudd, P., Zhang, Y., Barker, D., Pan, X. & An, S. 2004. "Flood event modelling with predictive simulation model and visualisation in the Alice Springs town basin, Central Australia". *Flood Forecasting and Management with GIS and Remote Sensing.* Guangzhou (November)

Sarib, R. & West, G. 2001. "Cadastral reform in the Northern Territory 2002 Update". *2001 – A Spatial Odyssey 42nd Australian Surveyors Congress.* Brisbane (September)

West, G. 1998. "Establishment of the Geodetic Geocentric Datum of Australia 1994 – the Northern Territory Field Survey Component". *Discover Your Future – Reflect on Your Past. 24th National Surveying Conference*. Institute of Engineering and Mining Surveyors (Australia). Alice Springs (October).

APPENDIX 1 - NTSDI – CORE DATA SETS

TOPIC	DATA SET	DATA TYPE **S**patial **I**mage **A**ttribute	DATA SET TYPE **B**asic **C**omposite **D**erived	CUSTODIAN	AUTHORITY
Primary Reference	Geodetic	S / A	C	DIPE – LID	Surveyor-General (S-G)
	Aerial Photography Archive	S / I / A	C	DIPE – LID	Director Land Information Services (LIS)
	Geophysical Imagery	S / I / A	C	DBIRD	
	Topographic	S	C	DIPE – LID	Director LIS
	Bathymetry	S	B	DIPE – LID	Director LIS
	Processed Satellite Imagery Index	S / I / A	D	DIPE – CNR	
Administration	Land Parcels / Cadastre	S / A	D	DIPE – LID	S-G
	Easements	S / A	D	DIPE – LID	S-G
	Land Tenure Details	A	C	DOJ – RGO	RG
	Land Values	A	B	DIPE – LID	V-G
	Street Address	A / S	B	DIPE – LID	S-G
	Administrative Boundaries (Town, Suburb, Locality, Local Government)	S / A	C	DIPE – LID	S-G
	Electoral Boundaries	S / A	B	NTEO / DIPE	S-G
	Other Administrative Boundaries	S / A	C	DCM	
	Mining Exploration Tenements and Licences	S / A	C	DBIRD	
	Petroleum Exploration Tenements and Licences	S / A	C	DBIRD	
	Place / Feature Names	S / A	B	DIPE – LID	S-G
	Interests in Land - Heritage Sites	S / A	C	DIPE – OEH	
	Interests in Land - Aboriginal Sites	S / A	B	AAPA	CEO AAPA
	Interests in Land - Restricted Areas	S / A	C	DIPE – PLANNING	Director Planning
	Interests in Land - Aboriginal land/claimed	S / A	D	DIPE – LAD	Director LA
	Interests in Land - Protected Catchments	S / A	D	DIPE – CNR	
	Interests in Land -	S / A	B	DIPE – CNR	

TOPIC	**DATA SET**	**DATA TYPE** **S**patial **I**mage **A**ttribute	**DATA SET TYPE** **B**asic **C**omposite **D**erived	**CUSTODIAN**	**AUTHORITY**
	Soils Conservation				
	Interests in Land - Parks and Reserves	S / A	D	DIPE - PARKS	
Natural Environment	Soils Types	S / A	D	DIPE – CNR	
	Vegetation Communities	S / A	D	DIPE – CNR	
	Geology	S / A	D	DBIRD	
	Biogeographical Regions	S / A	D	DIPE - PARKS	
	Terrestrial Fauna Classification	S / A	D	DIPE - PARKS	
	Marine Fauna Classification	S / A	D	MAGNT	
	Feral Animals	S / A	B	DIPE - PARKS	
	Land Units	S / A	C	DIPE - CNR	
	Land Systems	S / A	D	DIPE – CNR	
	Areas subject to natural hazard - Flood	S / A	D	DIPE – CNR	
	Areas subject to natural hazard - Storm Surge	S / A	D	DIPE – CNR	
	Areas subject to natural hazard - Contaminated Sites	S / A	D	DIPE – EHD	
	Weeds	S / A	D	DIPE – CNR	
	Climate	S / A	D	DIPE – CNR	
	Hydrology	S / A	C	DIPE – CNR	
	Water Quality	S / A	D	DIPE – CNR	
	Oceanography	S / A	C	To be agreed	
	Fishery Biology	S / A	C	DBIRD	
	Land Cover	S / A	D	DIPE – CNR	
Socio-Economic	Census Districts	S	B	TREASURY*	
	Demography	A	C	TREASURY*	
	Planning Zones	S / A	B	DIPE – DAS	Director DAS
	Strategic Planning / Control Plans	S / A	C	DIPE – PLANNING	Director Planning
	Current Land Use	A	C	DIPE – DAS	Director DAS
	Development Proposals	S / A	C	DIPE – DAS	Director DAS
	Mineral and Energy Resources	S / A	D	DBIRD	
	Fishery Resources	S / A	C	DBIRD	
	Aquaculture Resources	S / A	C	DBIRD	

TOPIC	DATA SET	DATA TYPE **S**patial **I**mage **A**ttribute	DATA SET TYPE **B**asic **C**omposite **D**erived	CUSTODIAN	AUTHORITY
Built Environment	Construction Details	A	B	DIPE – BAS	Director BAS
	Road Centrelines	S / A	B	DIPE – LID	Director LIS
	Rail Centrelines	S / A	B	DIPE – LID	Director LIS
	Marine Transport	S / A	B	DIPE – TRANSPORT	
	Aviation Features	S / A	B	DIPE – TRANSPORT	
	Electricity Supply Networks	S / A	B	PW	
	Gas Supply Networks	S / A	B	To be agreed	
	Water Supply Networks	S / A	B	PW	
	Waste Water Networks	S / A	B	PW	
	Storm Water Networks	S / A	B	DIPE * – LID	
	Telecommunication Networks	S / A	B	To be agreed	
	Bores and Wells	S / A	B	DIPE – CNR	

LID	Land Information Division
LAD	Land Administration Division
OEH	Office of Environment and Heritage
CNR	Conservation and Natural Resources
DAS	Development Assessment Services
BAS	Building Advisory Services
PLANNING	Planning
TRANSPORT	Transport
PARKS	Parks
PW	Powerwater Corporation
DBIRD	Department of Business, Industry and Resource Development
DCM	Department of the Chief Minister
AAPA	Aboriginal Areas Protection Authority
DOJ	Department of Justice
RGO	Registrar-General's Office
MAGNT	Museums and Art Galleries Northern Territory

BIOGRAPHICAL NOTES

Phillip RUDD, Director of Land Information Systems (NTLIS) in the Land Information Division of the Northern Territory Government's Department of Infrastructure, Planning and Environment, Licensed Surveyor in the Northern Territory and Victoria, Batchelor of Applied Science (Surveying) from the RMIT University, Foundation member of the Australian Spatial Sciences Institute, Member of the Institution of Surveyors, Australia.

Phillip moved to the Northern Territory in 1982 to take up a position as Licensed Surveyor after 8 years working in the private sector in Victoria, Australia. He quickly realised that surveying in the hot tropical sun wasn't much fun and moved into a computer systems job in the Land Management Division of the then Department of Lands. It was here that he first became involved in the Land Administration Information System in 1985.

Phillip is currently the Director of the NT Land Information Systems (NTLIS) Program for the Department of Infrastructure Planning and Environment which includes the Integrated Land Information System (ILIS) and the GIS support groups. As Director of the NTLIS he has whole of NT Government service obligations as well as supporting the Department's own spatial information business systems. In this role, Phillip has been involved in the planning, development and implementation of the NTLIS architecture and spatial data infrastructure for the NT Government over the past 15 years.

Phillip is actively involved in national coordination committees which include

- the Intergovernmental Committee for Survey and Mapping's Cadastral working Group;
- the Australian New Zealand Land Information Council's (ANZLIC) Emergency Management/Counter Terrorism Working Group and the Spatial Data Infrastructure Steering Committee's Technical Working Group;
- the Australian Registrars' Electronic Conveyancing Steering Committee's (ARECSC) Data Transfer Standards National Working Group and the Technical Reference Group for electronic conveyancing
- various national working groups and committees as the NT's representative and the coordinator for the NT's contribution to some of the themes in National Land and Water Audit atlas

Phillip has worked as a land information management consultant and technical adviser in Sarawak, Taiwan, the Solomon Islands and in China where he provided a major input of 15 months on AusAID's Hainan Land Resource Fundamental Information System Project in 1996 and 1997.

Robert SARIB, Manager, Survey Services in the Land Information Division of the Northern Territory Government's Department of Infrastructure, Planning and Environment, Licensed Surveyor, Foundation member of the Australian Spatial Sciences Institute, Member of the Institution of Surveyors, Australia, and Vice Chair of Administration for FIG Commission 5 – Position and Measurement.

Robert Sarib obtained his degree in Bachelor Applied Science – Survey and Mapping from Curtin University of Technology Western Australia in 1989. He was registered to practice as a Licensed Surveyor in the Northern Territory, Australia in 1991 and achieved this during his employment with the Northern Territory Government. Since then he has work in the private sector as a cadastral surveyor, and more recently re-employed by the Northern Territory Government to manage the NT Geodetic Infrastructure and administer the Survey Services unit of the Surveyor General's office. He also holds a Graduate Certificate in Public Sector Management received from the Flinders University of South Australia.

Mr Sarib is currently a member of the FIG Commission 5.2 Working Group – Reference Frame in Practice, and the Northern Territory delegate on the Australian Inter-governmental Committee on Survey and Mapping - Geodesy Technical Sub Committee. He is the Junior Vice President of the Institution of Surveyors Australia and the Northern Territory representative for the Land, Hdyrographic, & Survey Commission of the Spatial Sciences Institute of Australia. He is also a board member of the Surveyors Board of Northern Territory for licensed or registered surveyors.

CONTACTS

Mr Phillip RUDD
Department of Infrastructure, Planning and Environment
GPO Box 1680
Darwin NT
AUSTRALIA
Tel. +61 8 89244144
Fax. +61 8 89244045
Email: phillip.rudd@nt.gov.au
Web site: www.ntlis.nt.gov.au

Mr Robert SARIB
Department of Infrastructure, Planning and Environment
GPO Box 1680
Darwin NT
AUSTRALIA
Tel. +61 8 89996081
Fax. +61 8 89997750
Email: phillip.rudd@nt.gov.au
Web site: www.ntlis.nt.gov.au