Map Your Files and File Your Maps: Managing the Infrastructure Data that GIS Can't Manage

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ABSTRACT

GIS users require a broad view of spatial information, the ability to work with large areas, and powerful analytical functions. Engineering surveyors create and work from sets of detailed drawings and models, with spatial information, and require a rich set of 2D and 3D geometry-based engineering and survey design functions. The needs of the GIS user are best met by a continuous multi-user database. The engineering surveyor's requirements continue to be best met by a model and drawing paradigm.

Land surveyors work with the cadastre which is composed not only of graphical spatial data but is also represented by land titling documentation and certificates, not easily managed by GIS systems.

Yet, despite distinct roles, GIS professionals and surveyors very much depend upon each other to conduct their work. GIS users need accurate information on as-built conditions and engineering and land surveyors need the context of plans to create their designs. Operational staff need access to all of this information.

This paper will discuss the unique issues of providing a corporate management system for files and documentation which have spatial relationships and will provide examples of the application of the new technology from two areas:

- Interoperability of file management system for asset records with GIS systems within a Electricity Utility context
- Spatial file & document management for cadastral and titling applications for two developing nations; Honduras and Lebanon

It will show that GIS systems are well complemented by a Spatially Enabled Management Environment for the capture, management and publishing of files and documents best managed and accessed in their original formats.

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1. INTRODUCTION

Unbridled enthusiasm for the way GIS systems can bring disparate geographical datasets together within one view for better comprehension and more rigorous analysis has led many people to the conclusion that, within enterprises concerned with land, environment or dispersed asset management, corporate information systems should be GIS-centric.

It is generally agreed that GIS data is best ultimately stored in a relational database where it may be accessed by any GIS technology that conforms to Open GIS Consortium (OGC) standards. In this way, the GIS data model is really an extension of the database record model and enterprise database vendors are providing more capability for such data management and analysis. Oracle's 10G technology provides the most modern example. (Oracle, 2004)

However, this is to ignore the fact that many vital datasets within such organizations are of a form that is inappropriate for a GIS to manage, e.g. data which is created and stored as discrete files.

Such file-based organizational content includes vector files, models, scanned drawings, documents, contracts, spreadsheets, even non-database managed GIS files such as MapInfo tab files and ArcView shape files, and much more. All this content has one thing in common – the information can be related spatially to a point or region of interest, or to an asset, but is created as a single or related group of files.

This data management issues is not unique to GIS. Insurance companies do not attempt to normalize insurance contracts to sections, subsections, paragraphs, sentences and words and then reconstruct them when it is time to review the contract. Rather, they pick the essential particulars of the contract and store this information in the database and a link is maintained to the signed scanned contract.

While Document Management Systems (DMS) such as Documentum and FileNET have been developed to meet the requirements of office-type file management, typically DMS systems fail to cope with the complexity of engineering and GIS file management.

2. SPATIALLY ENABLED MANAGED ENVIRONMENT

Map and engineering drawings most naturally exist as documents. At milestones in the management of infrastructure, the map or the drawing must be stored, signed, and sealed as a legal document, and in both electronic and paper form. The graphics in each version persist and the intent of the originating author is preserved.

Such documents have a geographic context or relate to a location but best stored in an appropriate file or document management systems. This system can provide a spatially management environment if the attribution stored about the file also includes the geographic context or location.

This can be achieved by the addition of spatial attributes to those already stored.
A spatially enabled managed environment must:

- Support input, retrieval, and display of documents based upon location;
- Integrate map management;
- Abstract the user from differing coordinate systems; and
- Include the necessary infrastructure to support interoperability with GIS.

The key to enabling this functionality is the seamless integration of spatial location as an index in the managed environment.

2.1 Spatial Location

A "spatial location" is geometry such as a point, a line, or a polygon that can be specified in any coordinate system such as latitude/longitude or some cartographic projection. When a spatial location is associated to a document, the document can be retrieved and displayed based upon spatial attributes. Since all infrastructure exists in true geometric space and elevation is critical in engineering, 3D spatial locations are also indexed. Bentley Systems provides such as solutio. It allows for 1:n relationships between a spatial location and the object to be located (that is, a document or folder). Once a spatial location is assigned to a project folder, all contained documents such as design files or specifications may inherit the same location.

Source documents originate from a variety of sources and use many coordinate systems; in fact, many projects routinely require the use of several different coordinate systems. It would be an undue burden to require that all documents be transformed into the same coordinate system, and therefore the Bentley system abstracts the user from this concern.

A Universal Coordinate System is supported, the default being a Geographic Lat/Long system on the WGS84 datum. Each document is indexed to this universal index; however, the original coordinate system of each document is preserved. This implementation enables search of documents across the boundary of different coordinate systems. Searches are very fast, even with thousands of documents. When checking in a document and creating an association with its spatial location, a valid coordinate system must be identified.

It is critically important that the capture of spatial location be as unobtrusive as possible. Therefore, Bentley's solution adopts a flexible process that minimizes user intervention but maximizes effective capture of spatial location.

When documents are checked in to the managed environment, Bentley adopts the following location capture strategy:

- For documents with inherent coordinate systems – Design files, GeoTiff images, Shape files, and so forth - the document location is automatically deduced; and
- For documents that are a-spatial, such as MS Office documents, a cascading strategy is used to capture location:
  - The document can co-opt the location of the folder into which it is inserted;
  - The document can inherit the location of any other folder or document; or
  - The user is presented with a map, on which s/he can navigate, and choose a location.

User applications may also be written to determine the appropriate location of a document based upon whatever spatial information is contained in, or associated to, the document. Many organizations use some standard (such as defined tags, file name standards, metadata in a sister file, and so forth) that can be programmatically leveraged for deducing spatial location intelligently.

2.2 Spatial Navigation and Query

Once spatial locations are registered, documents or sets of documents can be located through intuitive queries. Any mix of spatial and a-spatial attributes can constrain a query, and be used in combination with spatial navigation.

Typically, the user will use readily available spatially related attributes such as address, place name, postal code, area code, or coordinate. The result can then be displayed in a simple list of documents, or on a map.

To integrate navigational capabilities in a variety of client applications, an Active X Control, called the Spatial Navigator, is provided. This control constitutes a ready-to-use component for Bentley products, as well as an open technology platform for custom clients.

The Spatial Navigator will be implemented in many Bentley clients. A simple HTML browser client will support Internet access, controls will be provided for hand held devices, and a Windows-based application will support intranet use. MicroStation V8 users can leverage the spatial interface to locate any design of interest.

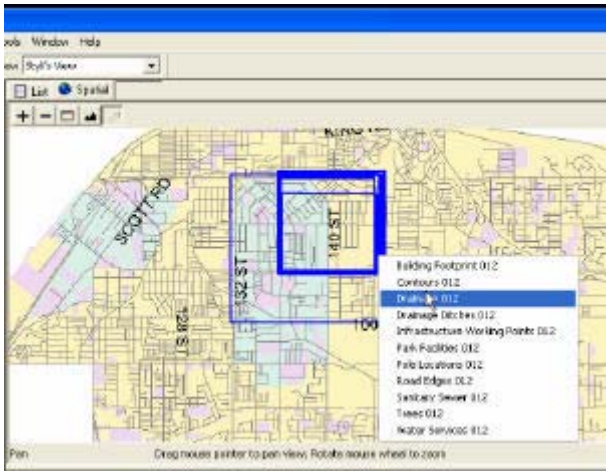

Fig 1. The Spatial Navigator Interface (Mann, 2003)

3. ELECTRICITY UTILITY: ENERGEX, Queensland, Australia

3.1 Data Management Requirements

ENERGEX, a leading Australian energy company, upgraded its drafting and document management system to an integrated engineering design and content management system.

Since the mid-1980s, ENERGEX's Transmission Design Department had used a mainframe system for drawing design and document management. In 2001, following a review of its requirements, ENERGEX chose a Bentley solution, ProjectWise, to replace its existing system. ENERGEX's Transmission Design Department works in a managed environment built around the Bentley Systems content management solution, the MicroStation design platform, and discipline-specific applications. This environment has reduced the time and effort needed to share information among disciplines, suppliers, and clients.

ProjectWise is intended to serve as a central storage place for content once held in several locations, which improves access to information and ultimately response and repair times. These types of benefits are critical to large companies such as ENERGEX, which has AUD $3.7 billion in assets, employs nearly 3,000 people and serves more than 1.1 million customers throughout eastern Australia and in New Zealand.

3.2 Migrating legacy records, customizing the new system

Changing over to the new system necessitated a coordinated approach. 38,000 old drawing files were translated into the MicroStation DGN format, and 240,000 drawing records were imported into the ProjectWise database. ENERGEX also had the Bentley system extensively customized to mimic the work processes of the other system, so users would require less retraining. By June 2002, the Bentley solution was in production.

The solution for the substation design department included ProjectWise, MicroStation, Elementary Electrical Diagrams (EED), and others.

ProjectWise also has the potential to enable ENERGEX to share information across a number of locations. They intend to deploy ProjectWise to 40 ENERGEX staff in different locations, so they can also use the application to locate drawings.

It is possible for ENERGEX maintenance workers to locate the files themselves, via ProjectWise, without help from the plan library or the design department, which may be some distance away. Users are able to plot the drawing at their own local printers, if a digital version is stored in ProjectWise. In addition, the user-friendly interface of the Windows-based file structure in ProjectWise is easier to navigate, which speeds up the time taken to locate files.

3.3 Boosting productivity

ENERGEX's Transmission Design Department can also gain productivity improvements as they can now share files in different formats, negating the need to reformat files. MicroStation allows viewing, referencing, editing, and saving files in AutoCAD's DWG format. They no longer need to translate AutoCAD documents from other ENERGEX departments, suppliers, or outside clients.

This is a significant benefit, as about 10 percent of the team's work is done for other Australian energy utilities, some of which use AutoCAD. The circuitry design tool EED also saves time by producing control panel designs and then spinning off bills of materials required for the project. The materials with the designs go to electrical workers, who fabricate the control panels. Finally, ENERGEX's new managed environment for design and document management, built on Bentley solutions, has helped ENERGEX to streamline processes and, as a result, be more time-efficient.

4. DEVELOPING COUNTRIES LAND INFORMATION MANAGEMENT 1

4.1 Unified System of Registries (SURE), Honduras

With a population of 6.6 million and 2.5 million land parcels to manage, Honduras is still a developing country with about 80% of the population excluded from the formal capital markets.

The Honduran government decided to automate the property rights administration as a contribution to improve the quality of life of the Honduran citizens. With the World Bank support, the PATH project (Land Administration Project of Honduras) has built SURE (Unified System of Registries) in order to manage the physical, legal and administrative information of every parcel in the Honduran territory. (Meriam, et al, 2004)

Based in Java, Oracle database and Bentley technologies the SURE is a multi layer web based system that automates the process of creating, administrating and publishing interest

information. Thanks for its design, SURE can be used in territory management, forestry areas administration and other related subjects.

SURE is an information system designed to modernize the process of registering the cadastral and land possession information nation-wide.

SURE areas of management includes:
- Registry of the Immovable Property (Real State), Forest, Mercantile, Agrarian, Administrative and State property.
- Automation and preservation in digital Images of Books of the Immovable Property.
- Management of the Cadastral maps (geo-referenced) and its integration with the alphanumeric data of the Registry.

The system directly supports the efforts of decentralisation of operations, which is the reason for the direct involvement of the municipalities in the cadastral update process. Additionally, it will involve other state organizations with the purpose of reaching one of the fundamental objectives of PATH Project: to support the process of regularisation of land possession.

It offers alphanumeric and geo-spatial information that supports the inscription process done in a proper way based on objective criteria, warranting the legal security in the land possession and other goods. Based on the registry technique of inscription in Real Folio (focused on the parcel not in person), it allow people to enquire about a good with all its affections in a single transaction.

The system will allow the remote inquiry of data, in such a form that the interested people and institutions will be able to connect remotely and obtain data related to the goods, its rights and the owners.

The SURE is based on a modern design, using a multi-layer architecture that it allows agility and security of the transactions.

It also aims to automate the capture, management, publishing, and sharing of information, allowing the creation of a common database bank, for all the participant institutions:
- Secretaries of Finance, Presidency,
- Technical Secretary of the Economic Cabinet (UNAT),
- Government Secretary, Natural Resources and Environment Secretary (SERNA),
- Honduran Corporation of Forest Development (COHDEFOR),
- Universities and Education Secretary,
- Public Works, Transport and Tenement Secretary (SOPTRAVI),
- Health Secretary,
- Technical Secretary of Cooperation (SETCO),
- Honduran Fund of Social Investment (FHIS),
- National Institute of Professional Formation (INFOP);
- Agrarian National Institute (INA),
- Road Fund

– National Bank of Agricultural Development (BANADESA).

PATH (Project of Honduran Land Management) will manage the process of regularization of the ownership rights in Honduras for the next 12 years, using technology that is scalable and easy to maintain. Together with the PBPR (Project of Forests and Rural Productivity), PATH uses trend analysis to carry out the generation of management plans for the administration of forests, registries and forests cadastre. The final goal of the project is to use information technology to strengthen the quality and productivity of land use policies.

Bentley Systems geospatial solutions and cadastral management systems were implemented including projects in the areas of hydraulic services, light and urban infrastructure.

It is important for Municipalities to have an inventory of their assets, updated and consistent, within a maintenance and management system, easy to use, with options of information analysis to help to evaluate and plan the fiscal actions of the Municipality. This is a basic requirement as its use supports fiscal purposes, specifically for determining cadastre values of the assets and in calculating taxes.

The system of Cadastral Management helps solving the most common problems that municipalities face such as:
- Evasion of tax payment as land use rights, water, and so on, caused by lack of cadastral registries.
- Inconsistencies in the information, that creates distrust in the citizenry.
- Low functional cadastral cartographic information systems that not resolve in time the problems of the people.
- Difficult and unsuitable access to information that restrains a real analysis for the update of billing wages and construction and land value.
- Cadastral information not updated and lack of control in the cadastral management processes.
- High costs in the cadastral operation.

5. DEVELOPING COUNTRIES LAND INFORMATION MANAGEMENT 2:

5.1 Integrated Cadastre & Registry System (ICRS), Lebanon

This project was conducted for the Ministry of Finance, Directorate for Land Registry and Cadastre during the period 1999 – 2005 by KLM Aerocarto B.V.

The general objective was to convert 6000 analogue maps into digital files and automate a number of Cadastral procedures to have a nation wide automated Cadastral system for Lebanon. Currently additional parcels are being converted and implemented and internet-functionality for banks (e-Cadastre) is being tested. The ultimate aim of the project was to create a data set and process to support an “e-Cadastre” for Lebanon where an e-Cadastre is defined as: e-Processes + Business Rules + e-Data. (Huberts, 2004)

This project contains the following major components:
- Development of Application Systems and Databases
- Conversion of Cadastral Data
- Technology Transfer
- Implementation of Integrated Cadastral and Land Registry System

The ICRS Project was conducted in three main phases:

5.2 Phase 1: Data Preservation,

This phase involved preservation of the data contained on the often fragile original documents and records which comprised the source media. There were three main data source types which were scanned:
- Cadastral Maps including Kartoons, Kalks and transaction-documents
- Control Point Books; Scanning and (Dual) Data Entry
- Area Registers; Scanning and (Dual) Data Entry

5.3 Phase 2: Data Preparation

5.3.1 Rubbersheeting (Geo-referencing) of Cadastral Maps

This was the most important activity for maintaining the accuracy of final digital coordinates. The Bentley Descartes application provided tools for automation. The accuracy (compared to field coordinates) achieved was:
- 3 - 5 cm for scale 1 : 500
- 5 – 8 cm for scale 1 : 1.000
- 8 – 12 cm for scales 1 : 2.000

5.3.2 Rubbersheeting of Kalks and land transaction documents

This was carried out for the completion of data (i.e. bad areas on maps) and for improving the currency (i.e. addressing problems with out of dateness) of Cadastral Maps

5.4 Phase 3: Data Conversion

5.4.1 Vectorisation of Map Information

- Construct and conform to a detailed Conversion Procedure Manual to provide guidance for conversion operators in resolving decisions involved in all ‘if-then’
- Standardization of features
- On-line / continuous comparison with Area Register Database (difference vector parcels with administrative record should be within the X-percentage)

5.4.2 Completion / Updating

- All parcels records in Area Registers which are not equal zero must have graphical parcel
- Edge-matching between cadastral maps, cadastral areas and cadastral regions / offices

5.4.3 Tracking / Synchronisation

- Tracking of all transactions (cadastral map and/or area register updates) after moment of scanning
- Synchronisation of these updates (analog on maps and digital in automated cadastral system)

When the data capture phase is complete, the project will move on to implementation of the advanced aspects of:

- Issuing Affidevits to the local banking sector
- Providing digital data for the non-mapped cadastral areas
- Providing digital Cadastral data to municipalities for applications such as Urban Planning

This project ultimately combines data that is suitable for entry to a GIS environment with data that is best retained in spatially referenced digital files. Together, these data sets service the provision of services for land management and land transactions and contribute to building a more secure economy for Lebanon.

6. CONCLUSION

In both asset record representation and cadastral record information management, while some data is suitable for conversion for GIS management, much of the data is better stored and accessed as original digital files. These files are best managed in a document management system that is specially designed for complex engineering and mapping data types and can provide a spatial index for faster and more intuitive searching and accessing.

Such a system provides the organisation with a Spatially Enabled Managed Environment. This system can be integrated with any existing GIS or other enterprise information management systems to provide comprehensive file management and access.

These systems are currently being implemented in the developed world particularly in distributed asset management such as with major utility organisations, and they have the potential to assist in the economic development of developing countries by providing better land administration and transaction processes.

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BIOGRAPHICAL NOTES

Specific Responsibilities
Andrew is responsible for all product, services and maintenance sales in the Geospatial market (i.e. Government, Utilities and Telecommunications) in South East Asia and Australia / New Zealand. Managing Bentley Geospatial staff in those countries and local resellers, Andrew is building up Bentley's presence in developing countries on the back of successful growth and experience servicing the needs of the Australia / New Zealand Utilities market. Central to Andrew's industry philosophy is the goal of providing IT systems that put useful data in the hands of decision makers, without requiring the expertise level of those who created the data.

Past Experience
2000 – April 2003, Bentley Systems: Australia / New Zealand Regional Director. In 2002, Andrew lead the Australia / New Zealand Region Sales team in generating its highest revenue level since Bentley was established in Australia in the mid-Nineties. This was based on sales into the Plant & Process, Civil and Transportation, Architecture and Building, and Government and Utilities industries and included professional services and training. Andrew received the Winners Circle award from Greg Bentley in January 2003.

1998 – 2000, Intergraph Corporation: Southern Australia Account Manager: Andrew focussed on Government, Utilities and Transportation accounts while based in Melbourne.

1996 – 1998, Waitakere City Council, New Zealand: GIS Project Manager: Andrew, together with a team of developers and cartographers, managed the implementation of the Waitakere GIS and the successful completion of the District Plan mapping project. This project, contributed to the high level of environmental management for which the Council is well known. It allows the Council to control changes to the natural environment, as well as built-up areas, through planning regulations and to monitor and measure changes by comparison with a comprehensive GIS information database.

1981 – 1996, Andrew held a series of cartographic roles at government and commercial organisations including Melbourne Water, BP Exploration & WBCM Consultants.

Educational Information
B.Apps.Sc. (Cartography) RMIT 1995

Professional Memberships
Spatial Sciences Institute (Australasia)
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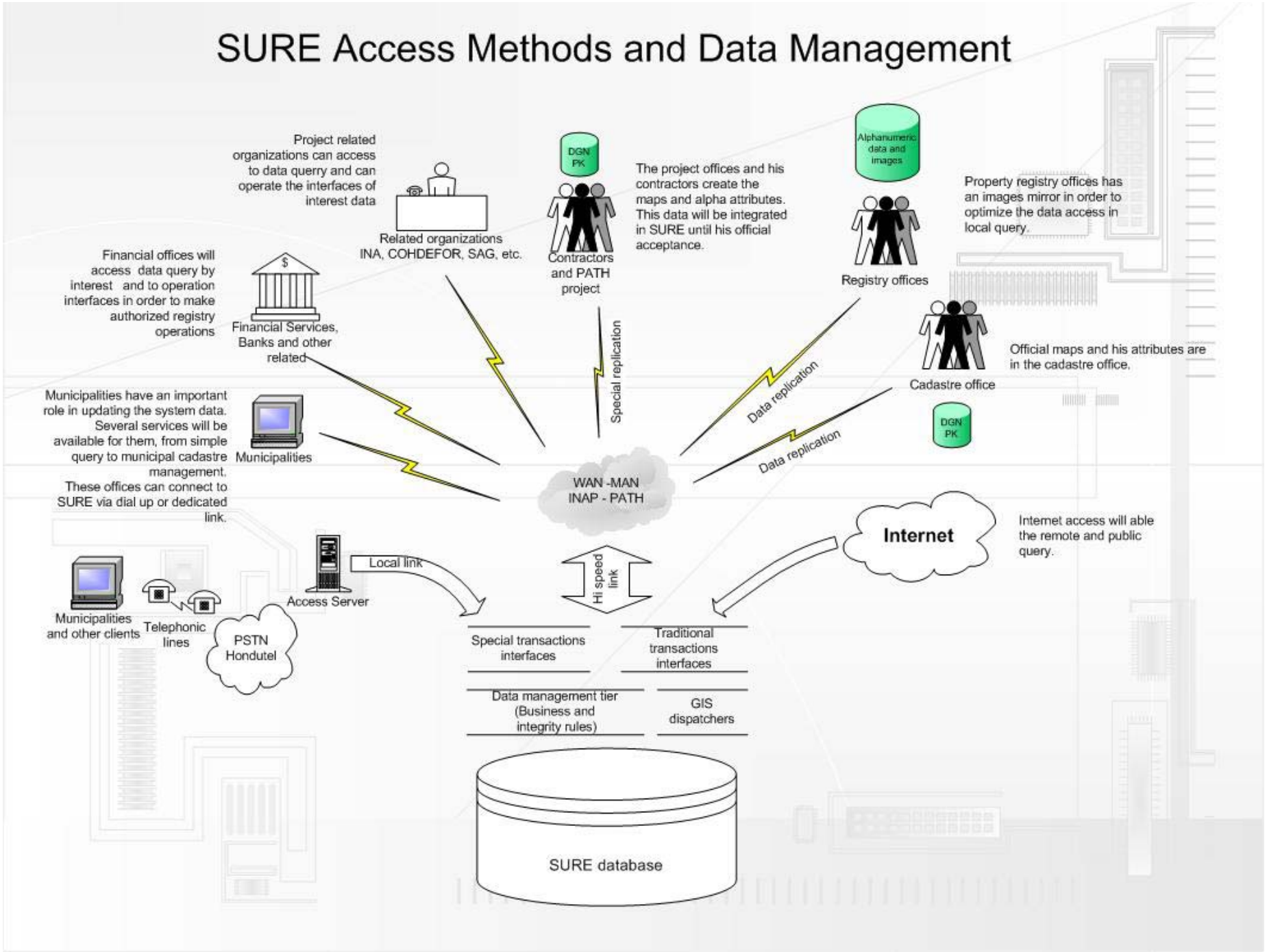

Figure 2. Information flow within the SURE Project