Rail Services GIS Experience

RAIL SERVICES AUSTRALIA

Our Experience Adds Value

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SUMMARY

Rail Services Australia, in conjunction with its client Rail Access Corporation, is implementing a spatial asset management system using GIS technology to provide enhanced management and operational opportunities. The underlying objective of the system is to rationalise the maintenance of data used by the diverse information systems in the operation of the rail infrastructure. Coupled with this is the need to provide improved viewing and analysis tools.

Unlike some other organisations, the GIS is not being implemented as a specific stand-alone project. Rather, the GIS is being implemented as a by product of other projects which require the spatial data and, in some cases, the functionality of the GIS to support their operation.

Data and applications are being progressively added as projects dictate. The basic Smallworld GIS functionality is being enhanced to meet the needs of users, taking advantage of Web browsing features to provide access across a wide geographical area. There is no limit to the number of people who can concurrently see and use the same data, unlike the paper based and island systems it is replacing.

The paper provides a brief review of past developments, an overview of current projects, the positive impact those changes are having on the business and a brief insight into how spatial information system technology is likely to be applied to meet the commercial needs of rail organisations, particularly rail organisations, in the 21st century.

The paper describes some of the benefits to be realised from utilising the latest GIS technology. A case study using the Electrical SCADANet Project is presented.

1. INTRODUCTION

Since 1st July 1996, the railway organisations in NSW have been split into the rail nfrastructure manager, rail service operators (freight and passenger) and rail infrastructure maintainers. Rail Access Corporation (RAC), the publicly owned rail infrastructure manager, has been responsible for: earning income from the rail operators; expenditure on the infrastructure; and returning a dividend to the State Government. The accredited rail service operators include, for passengers, City Rail, Countrylink, 3801 Limited and Great Southern Railway and for freight, Freight Corporation, BHP and National Rail.

The standard gauge line within NSW has been split into geographic areas or bundles. The infrastructure maintenance for each bundle is being competitively tendered by RAC and is held by an Infrastructure Works and Maintenance Provider (IWMP). At present Rail Services Australia (RSA) provides these maintenance services to RAC for the majority of the bundles.

One of these bundles is known as the Systems Bundle which provides certain systems support across the rest of the bundles. One of the support systems is the GIS spatial asset management system.

RAC's requirements for the GIS have been directed towards key components of the infrastructure to incrementally build a picture of the spatial location of that infrastructure on a single uniform base.

RAC has recognised the need for a single consistent, up to date 3D geospatial configuration controlled database incorporating all infrastructure throughout its network. Prior to July 1996, the railways had selected Smallworld GIS (Geographic Information System) as its preferred platform for corporate infrastructure data and MapInfo for the low end user interface. Since July 1996, this philosophy has continued with development being directed towards the Smallworld GIS becoming the corporate platform but interfacing (as seamlessly as possible) to other systems.

GIS has a number of significant advantages to CAD systems. One feature of the GIS is that attributes can be held against each object as well as its spatial location (in the geographical and/or schematic worlds). Another benefit is that GIS allows the 'tiled' CAD files to form a continuous 'view' of the geographic or schematic views of the electrical network, rail network etc.

Some of the differences between CAD and GIS are included in Figure 1.

GIS V CAD

CAD	GIS
Primary purpose is for production of plans	Primary purpose is for ongoing asset management in a spatial framework
Used for preparing design plans and work as executed plans, these plans form tiles across a geographic area	Plans are merged into a single continuous database enabling the viewer to scan the entire database very quickly and efficiently
Plans do not have any inherent intelligence in the data	Data has topology, analysis capability includes network tracing, point in polygon and proximity analysis
Projects tend to be piecemeal, no comprehensive geographic coverage	Data is built up on an object and/or geographic coverage basis
Display of data is limited by the content of each plan	Data can be displayed in any combination and at any scale subject to the user's access rights
No 'What If?' queries	Allow 'What If?' and comprehensive modelling scenarios to be evaluated
Each new plan usually requires the base information to be collected/updated at the time of drawing	Maintained with current information through configuration control procedures

Figure 1

2. NOTATIONS

Abbreviations appearing in this paper include the following:

AC	Alternating current
ACT	Australia Capital Territory
BHP	Broken Hill Proprietary
CAD	Computer Aided Design (Drawing)
CDROM	Compact Disc Read Only Memory
CEO	Chief Executive Officer
DC	Direct Current
DMS	Distributed Management System
GDA	Geocentric Datum of Australia
GIS	Geographic Information System
GPS	Global Positioning System
IAE	Integrated Asset Engineering
ISG	Integrated Survey Grid
IWMP	Infrastructure Works and Maintenance Provider
LIC	Land Information Centre, Bathurst NSW
LIMS	Land Information Management System
MIMS	Mincom Information Management System
NSW	New South Wales
OCS	Operations Control System
QA	Quality Assured
QC	Quality Controlled
RAC	Rail Access Corporation
RSA	Rail Services Australia
SCADA	Supervisory Control and Data Acquisition
SRA	State Rail Authority of NSW
TAMIS	TransGrid Asset Management Information System
TCS	Train Control System
TOW	Train Order Working
TRAMS	Total Railway Asset Management System
WAE	Work As Executed
WAYNET	Wayside (Devices) Network.

3. EARLIER PROJECTS

3.1 Rail Estate, SRA

Smallworld was first purchased by Rail Estate (a section within the State Rail Authority of NSW (SRA)) in 1995 following an exhaustive tendering, evaluation and bench marking process. Smallworld is being used by Rail Estate to manage the railway owned land holdings and easements. To assist the computerisation of these records into the Land Information Management System (LIMS), the computerised land parcel boundaries dataset of the adjoining non-railway corridor lands was purchased from the Land Information Centre (LIC) at Bathurst.

3.2 Freight Rail, SRA

During 1995, the other divisions of SRA sensibly adopted Smallworld as the corporate GIS software and MapInfo as the low cost Windows based GIS[1]. MapInfo was to be used for those applications which could not afford to wait for the Smallworld GIS to be implemented or would not benefit directly from a corporate approach to data collection and management.

In 1995, prior to the splitting of the SRA, Freight Rail developed a Smallworld application to manage the GPS (Global Positioning System) data collected during a Rail Mapping Project[2] in 1994. This project covered over 7,000km of mainly rural freight lines in NSW, with few metropolitan lines being included. An accurate centerline of the rail track as well as the position of other rail features such as signals, level crossings, turnouts and speed boards were recorded together with stereo video images.

Funds were also invested in the development of an application to import and manage the track alignment. Data could then be imported from databases maintained by the railway surveyors and displayed on the GIS.

3.3 CityRail, SRA

The GIS Project Manager, appointed in 1995, prepared a Master Plan[3] for GIS development in CityRail based on wide ranging interviews with potential rail clients. A prototype GIS[4] was developed using MapInfo for the Epping to Hornsby line. MapInfo was also used by Environmental Services to produce a number of reports.

3.4 Rail Services Australia (RSA)

With the establishment of RSA in mid 1996, the opportunity was taken to combine the fledgling GIS groups in CityRail and Freight Rail and place these within RSA. RSA inherited GIS workstations and software licences from Freight Rail including the GPS rail mapping data and the survey alignment package. Funding previously allocated for GIS projects was transferred to RAC.

In 1997, an Electrical GIS Pilot project was completed in the Lewisham/White Bay area for RAC[5]. An electrical application developed on Smallworld GIS was enhanced to reflect the specific requirements of electrical distribution and use within the rail environment. It included obtaining a copy of the LIMS and LIC datasets from SRA. The project clearly demonstrated to RAC the benefits of converting paper and CAD based records to a GIS. Based on limited information, the commercial evaluation indicated that a pay back period of 9 years would be needed to fund the computerisation of the high voltage AC electrical records. RAC decided not to proceed further with a GIS at that time.

In the second half of 1997, the GIS Group bid on the open market for an assignment with TransGrid. RSA was successful in winning the consultancy to prepare a specification for the procurement of TransGrid's GIS[6]. RSA were subsequently engaged to assist TransGrid in the bench marking of the tendered products and to prepare a specification for the video capture of the electrical transmission lines managed by TransGrid.

In 1998, following further presentations to RAC and informal discussions, RAC decided that it did wish to implement a GIS. RAC decided that the GIS would be funded from projects which would benefit from its development, such as the Electrical SCADA replacement project.

Also in 1998, RSA decided to contribute to the development of TRAMS (Total Railway Asset Management System) of which a track GIS module, is part.

3.5 Rail Access Corporation (RAC)

RAC has invested in its GIS through work undertaken by RSA. RAC's CEO John Cowling, during a demonstration of the GIS by RSA, indicated the GIS would become

the primary configuration controlled spatial database for all rail infrastructure in NSW. At present RAC is investing in the GIS to support its new electrical SCADA system and Train Order Working (TOW) system. A significant part of the projects is data conversion.

4. GIS, CAD & OPERATIONS

Figure 2 shows the intended relationship between the design (usually CAD), asset management and operational functions[8]. For the past 10 or so years, the design for railway infrastructure in NSW has been undertaken using CAD systems such as AutoCAD and Microstation. Projects have generally been undertaken with the design information being compiled specifically for each assignment. The schematic plans which are generally aligned to operational requirements have been found to be well maintained. The geographic records are generally not so well maintained. Updating of the design documents as work as executed (WAE) plans and storing these centrally for specific areas has been hit and miss. With the advent of the GIS and its wider availability, it is planned to make current operational geographical and schematic views of the network available to users.

5. CURRENT PROJECTS

5.1 SCADANET

By way of background, the present electrical SCADA system stands alone from other systems. The network schematic is maintained by the SCADA operators using a primitive and limited computer system.

The new electrical SCADA system has a two way interface between the distributed management system (DMS) and the GIS (see Figure 3). In turn the DMS interfaces to the SCADA. Interfacing of the GIS and DMS has required common naming conventions and an understanding of data structures by the respective systems.

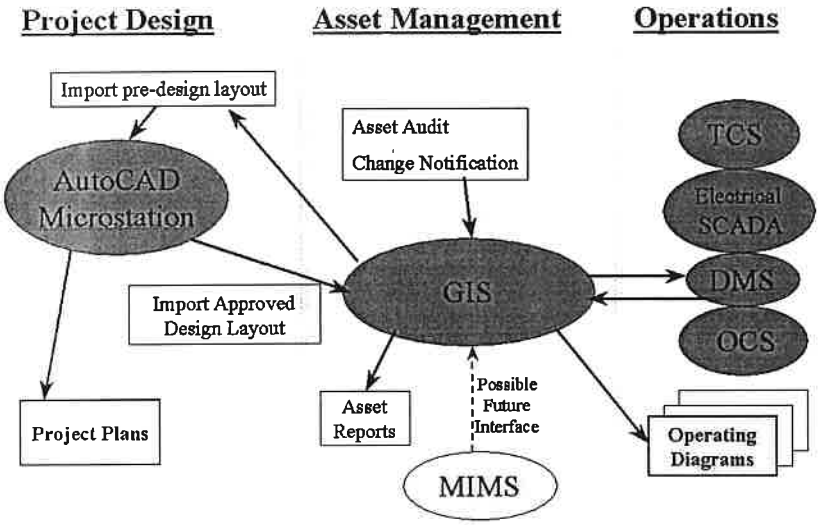

Figure 2

SCADANet commenced as an Electrical GIS Pilot in 1997 (see 3.4 above) and was broadened out to include the traction (or DC) electrical network. The driving force behind this project has been the desire to place on a single platform, information which is currently held on CAD and hard copy documents, interface this information to the new electrical SCADA and use the information for operational purposes. An added but important benefit is that the data collected on the GIS is consistent with any other data which is collected on the GIS for other projects.

The SCADANet GIS is being implemented by RAC to support the operational needs of the SCADA system. The SCADANet project is limited to the GIS mapping component and its interface to the DMS.

In 1999, an extensive data capture contract was awarded after the preparation of a capture specification, advertising, submission and evaluation. One of the reasons the successful contractor was awarded the first pilot area was its proposal to undertake data capture using Smallworld software. This meant that data could be transferred seamlessly in both directions between RSA and the contractor and it did not require any conversion changes if the data model changed. The geographic and schematic locations of the high voltage AC and DC networks have been captured using a combination of the Rail Estate and LIC data sets and the Integrated Survey Grid (ISG) coordinates incorporated in the CAD and hard copy plans.

Hard copy plans (over 1900) and CAD files (over 500) (most of which were based on ISG coordinates) were scanned or transferred onto CDROM and sent to the contractor. Concurrently the same objects were captured into the schematic worlds of Smallworld, including substations.

The schematic plans have been made consistent with the harmonised schematic projection[9] and integrated with the geographic plans (updated as required) with full GIS functionality now being available for the completed area.

The transformation of the data from CAD to GIS is resulting in the operators learning new skills as the maintenance of the CAD files for the operational diagrams is reduced. A significant advantage is that the 1500V DC operating diagram 'tiles' become part of a single continuous schematic on the GIS whilst still providing the opportunity to produce and print individual 'tiles'.

During the project, the data model has matured significantly in both its composition and the way in which it checks the data. In retrospect, it would not be advisable to commence data capture with a relatively immature data model. However, it needs to be recognised that a data model cannot be fully tested until populated with data so it is somewhat of a catch 22 situation.

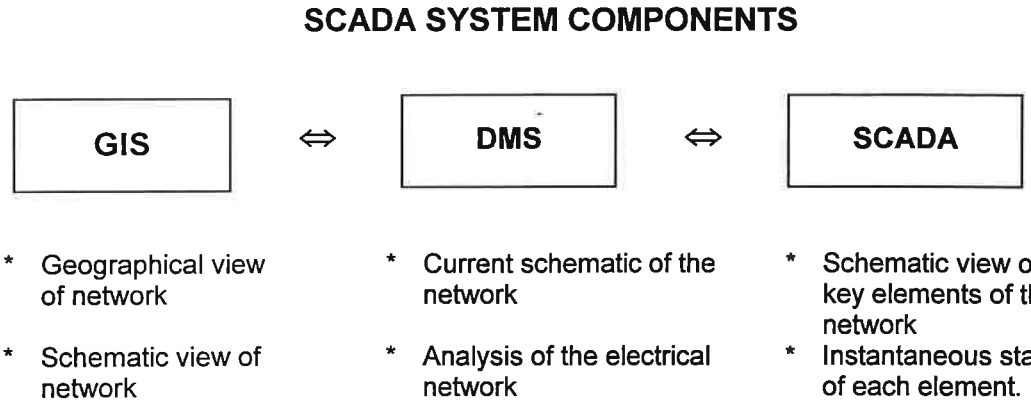

Figure 3

Testing of the data is largely undertaken, at least in the first pass, by the Quality Assurance/Quality Control (QA/QC) process written into the Smallworld logic. This has saved the operators and examiners a lot of time and effort in locating errors.

The operators of the high voltage electrical network in the control centers (being the electrical SCADA users) will be able to view a continuous AC and DC network on the GIS in both the geographic and schematic views (see Figure 4) as well as the more limited network available on the SCADA. Instantaneous readings on the SCADA network will be plottable on the GIS although it is not seen as a real time system. Similarly, any changes to the configuration of the network on the GIS will be available to, and displayed on, the DMS.

5.2 Train Order Working (TOW)

On some country lines where the frequency of trains is generally low, a new method of working the trains using GPS located on each locomotive is being introduced. Under the TOW system, trains travel under authorities issued to them by a train controller through a train radio system. By eliminating unnecessary stopping at the boundaries of each section of track, train running times, operating costs, brake wear and fuel consumption are all reduced.

At present, the GPS watchdog and other components require the visual display of the track, roads, rivers and other features to enable the location of the locomotive and its train. This has been provided by the Streetworks data set purchased from MapInfo which was itself captured from the best available topographic maps.

Typical Screen View of Substation on GIS

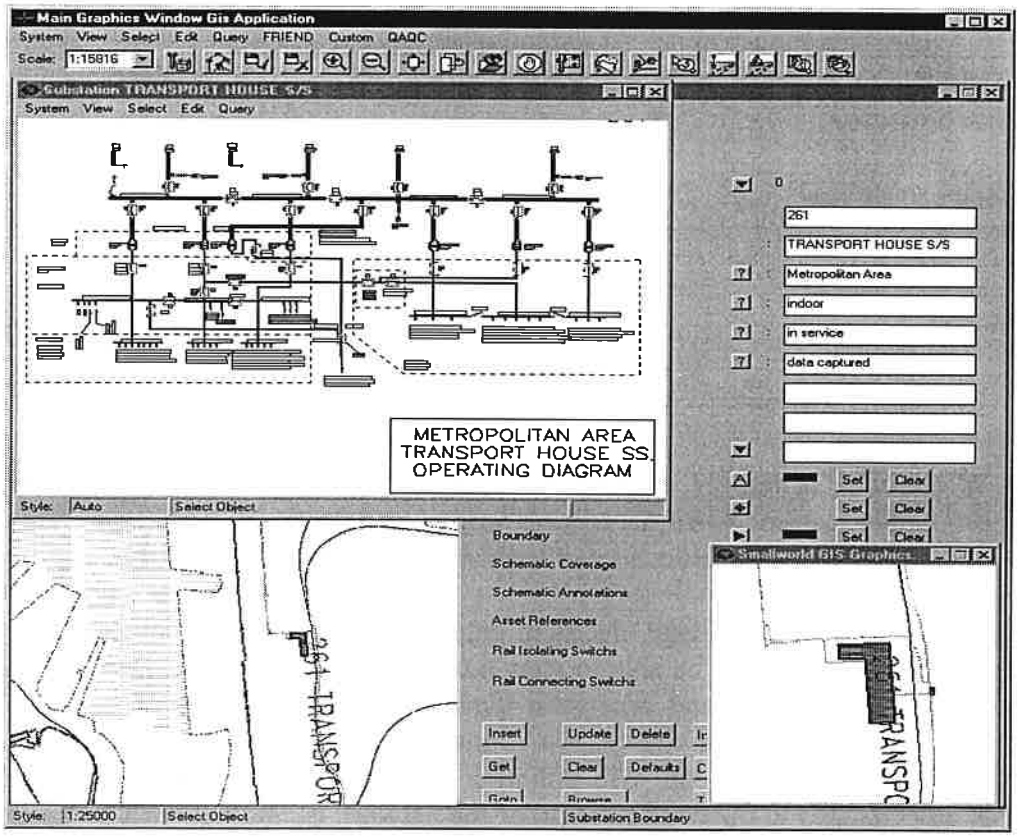

Figure 4

The schematic displayed on the present TOW system is manually updated. The development and population of the GIS TOW application has both the update and supply of the geographic and schematic views in mind. The GIS data model is being modified to include all objects for this project as well as the display of the track schematic (see Figure 5).

The GPS data provided by the rapid rail mapping project in 1994 is being used to confirm the coordination of survey alignment data (previously held in a text based database) and to coordinate string line data. In addition, the location and layout of rail loops and sidings and the TOW features are being added. The GIS will allow the display of both the geographic and schematic views, eventually providing direct update to all TOW components.

Typical Track Schematic View on GIS

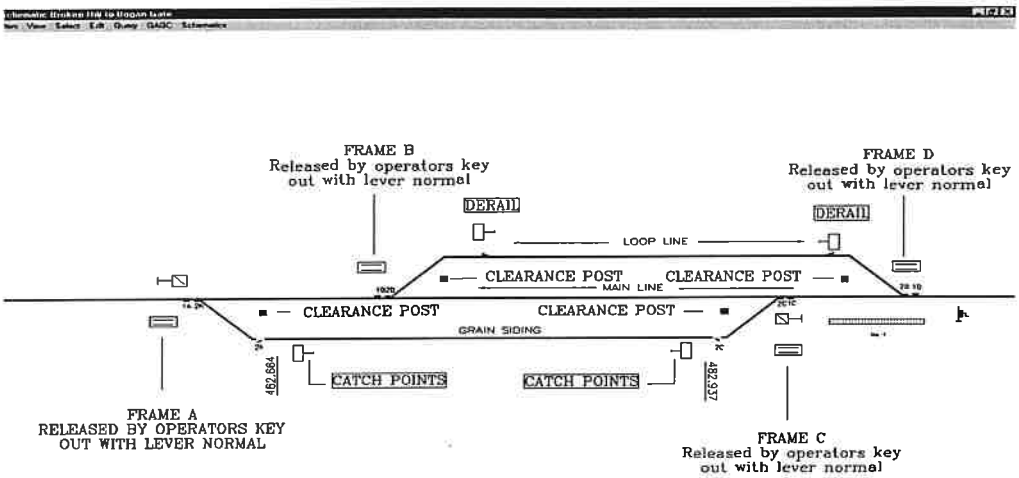

Figure 5

5.3 WAYNET

RAC has installed trackside devices to monitor aspects of the behaviour of both its infrastructure and operators. Amongst the devices are weighbridges (both slow and fast), automatic equipment identifiers (or tag readers), dragging equipment detectors, hot box detectors and wheel impact load detectors.

Underlying the WAYNET devices are their locations and attributes. Building upon the track alignment data captured by other projects (including SCADANet and TOW), the location of these devices is being included on the GIS. Extracts of this data are being transferred to the WAYNET website for display purposes.

5.4 Signalling

Many plans and diagrams, some of which are produced by CAD, support signalling in the NSW rail network. Use of the GIS to support the signalling functions is being developed and evaluated in conjunction with key operators.

As a first stage, the MS Access database used to support the train describer systems at Sydney, Strathfield and Sydenham was modelled on the GIS and successfully transferred to that system. In addition, the location of some physical signal assets was shown on the GIS.

Building upon the TOW project (see 5.2 above), the second stage is expected to examine the use of GIS for maintaining the signal schematics and the supply of these to systems for train and signal operator display purposes. The track schematic available from TOW will have other signal related objects added to it to enable the signal schematic to be generated.

5.5 TRAMS

The Total Railway Asset Management System (TRAMS) is being developed by RSA. Trackinfo, a GIS component of the system, is being developed as a method of allowing infrastructure bundle maintainers (IWMPs) to have access to, and use GIS to analyse various forms of maintenance data such as defects, costs, configuration and track performance.

5.6 Configuration Management Procedures

As part of RSA's Management System and the client systems, procedures are being prepared through the respective projects for the continued maintenance of the datasets. Configuration Management of each data element is seen as being an integral part of the projects. Capturing and confirming the present location and attributes of each data element only provides a short term solution. The continued maintenance of this data will provide the long term solution.

5.7 Access to the Railway's GIS

The primary GIS server is operated and maintained by RSA in Sydney. A number of workstations use the GIS server as well as workstations located at a cached site (about 14km away).

Also linked to the RSA GIS server is a server operated by RAC at its Sydney city offices. This replicated site has access via a dedicated line to RSA and to a RAC subsidiary site whose GIS server will also be a replicated site when this link is properly implemented. The development of the GIS network will include connections to the electrical operating centres at Prince Alfred Siding (Sydney) and Broadmeadow (165km to the north of Sydney).

6. FUTURE PROJECTS

6.1 Data Capture

The capture of spatial data and its attributes is expected to continue incrementally for some time, probably many years, on a needs basis. Data will continue to be added in a consistent and efficient manner and maintained in a timely manner. This will include the schematic view(s) and geographic view, as required. The present GIS data model will continue to be enhanced and expanded.

6.2 Design of Infrastructure

Whilst this is expected to continue using CAD products (such as AutoCAD and Microstation), the dependence of designers on the GIS for information is expected to increase. CAD files are produced for the project at hand but are not usually for the long term future management of the asset, unlike the GIS. The operators of the infrastructure are expected to be given access to the GIS.

6.3 Possessions Management

At present, the focus of GIS development is on the current configuration of the infrastructure. In future, our attention is expected to look at the changes proposed and the impact this will have on the management of possessions, train timetabling etc. The present system provides RSA and its clients with the capability to expand and meet these requirements.

6.4 Web Browsing

Use of the GIS over the local and wider area networks is already taking place. However, use of the web to modify as well as look at and analyse data is expected to fulfil an important need. Clients of the GIS, including IWMPs are expected to require fast and effective access to data both from office and field situations.

6.5 Maintenance of Reference Datasets

RSA, and its clients, are generally not in the business of funding the cost of maintaining datasets which are not core to their business, ie. used for reference purposes only. It is preferable for these datasets to be maintained by the responsible organisations but with online access.

The land parcel boundaries are an example. The maintenance of these boundaries is the responsibility of firstly, the organisation which registers proposed changes (usually the local council) and secondly the organisation which registers the agreed changes (Land Titles Office). Rather than the Land Information Centre providing each organisation with a GIS in NSW with updates, it makes good sense for each oganisation to have on line access to that updated land parcel boundary database. In the future, RSA may use the Smallworld functionality to access online external datasets as and when required.

7. GIS BENEFITS

Some of the benefits arising from the implementation of the GIS include:

- One consistent, reliable view of the network
- Better management of infrastructure maintenance, a reduction in the number of safety incidents and infrastructure failures
- Improved configuration control
- Ability to undertake network analysis and 'what if' scenarios
- Reduced cost of maintaining the data -phasing out of stand alone, one off databases which have limited access
- Schematic and geographic views will be in harmony, giving continuous state wide views
- Easier access to the current information, using Internet/Intranet facilities
- Less risk of non current plans and diagrams being incorrectly used
- Easier conversion of data to a new datum, for example, GDA 94 in 2000
- Integration of spatial with non-spatial data including images, documents, CAD drawings and text based databases
- User friendly graphical interface
- Improved allocation of funds to maintenance and capital works projects, and
- Easier integration/interfacing of spatial/non-spatial databases.

8. GIS FOR THE 21ST CENTURY

The GIS is being developed in NSW to support the operational needs of the railways. The present emphasis on both the high cost (Smallworld) and low cost (MapInfo) solution is likely to continue but these are likely to merge in the future. At present, data is selectively transferred between the two platforms.

During the early parts of the 21st Century, the emphasis will move from data conversion to the development of applications to use the data and to interface this data to other systems including railway infrastructure maintenance systems. The display of photographs and videos of the assets will occur at the touch of a mouse.

The configuration of a rail asset will include its spatial data management which will provide an integrated consistent 3D geospatial database for use by all rail clients including RAC, IWMPs and rail operators.

Use of the GIS by managers and operators is likely to increase, incorporating the Web browser facilities we have accepted in our day to day life. The GIS will become available to users, be they located in offices, on vehicles (including trains), at home or in the field.

9. CONCLUSION

In the 21st Century, the focus by the railway industry is predicted to be on the use of spatial systems for supporting its business. Duplication of data will be minimised. The planned, as well as the current, configuration of the infrastructure will be part of the GIS as well as the interfaces to other systems.

In NSW, RAC is seeing the benefits of its vision for information systems: each data item being updated only once to maintain configuration changes and data being transferred over the intranet/internet to many different systems, including CAD.

The present GIS is providing the ability to manage both the geographic and schematic information without replication. RSA's ability to support the operational and management needs of RAC and other clients will continue with GIS nto the 21st Century.

10. REFERENCES

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