Land Transport Authority
SINGAPORE

# Empowering Decisions to Enrich Land Transport for the Community

**ESRI International User Conference 2008**

## Executive Summary

This paper chronicles the Land Transport Authority (LTA) of Singapore journey in the adoption of Geographic Information System (GIS) technologies, and has since become an enterprise GIS information infrastructure that facilitates decision making in many facets of the business domains at LTA, and disseminates GIS information effectively within the organisation and across government agencies.

In 1999, with the advancements in GIS technologies and the intensifying business needs, LTA embarked on a quest to rationalise its GIS applications. It adopted a two-prong strategy; outside-in and inside-out approaches, in the conceptualisation of an enterprise GIS information infrastructure.

At the core of the enterprise GIS information infrastructure is the Land Transport GIS Data Hub, where all GIS information related to land transport infrastructure are managed and maintained centrally governed by established data management policies and processes to ensure data quality, consistency, accuracy, completeness, security and to facilitate data sharing and information disseminations. Leveraging on LTA's enterprise workflow and document management infrastructure, One-stop Retrieval & Infobank Interchange (ORBIT) infrastructure, it extends the framework to business functions such as a regulatory role, road management, civil engineering and traffic management.

The adoption of GIS technologies has brought forth several benefits to the community, such as safeguarding public safety, smoother travelling experience and pro-enterprise environment. Moving forward, LTA is committed to building a scalable land transport system with a robust infrastructure that can keep pace with a dynamic and growing population. It will also continuously review its strategies and approaches in light of the new challenges to meet our people's needs and aspirations; as a people-centred land transport system.

# Introduction

For Singapore to realise its aspiration to be a thriving global city, its transport infrastructure is critical. Managing land space is an on-going challenge in major cities around the world, especially in Singapore where a limited land area of approximately 650 square kilometres supports a growing population of 4.6 million. As the demand for greater mobility grows over the years, Land Transport Authority (LTA) of Singapore has to rise to the challenge of maintaining the delicate balance between effective, efficient use of land space and, at the same time, meeting the diverse land transport needs of the people to support a vibrantly growing economy, a bigger population, higher expectations and more diverse lifestyles.

By placing people at its heart, LTA endeavours to develop a more people-centred transport system that is technologically intelligent, yet engagingly human so that Singaporeans can look forward to a more integrated and user-friendly public transport system. This requires a continual process of planning and adjustments as our economy and society change over time.

The primary role of LTA includes:

- Planning, designing, construction, management and maintenance of the transit systems, roads and related facilities;
- Acting as agent of the Singapore Government in the administration, assessment, collection and enforcement of various taxes, fees and charges and other services relating to land transportation;
- Advising the Singapore Government on matters related to the land transport system; and
- Representing Singapore internationally in respect of matters relating to land transport.

## The Pioneering Years in GIS

The formation of LTA in 1995 through the merger of 4 public entities resulted in LTA inheriting disparate systems supporting a multitude of interlocking business processes with operations spread over more than 30 geographically dispersed offices. As a developer of land transport infrastructure, LTA is dependent on the digital maps to capture spatial engineering information, but the technology was fast-aging amidst increasing maintenance cost in legacy expertise.

Moreover, the swiftly changing urban landscape of a thriving Singapore demanded an expansion in its road and rapid transit system networks to match its phenomenal economic growth. More than 3,000 as-built drawings and on-site surveys are received each year for conversion into digital maps. Exchange of spatial information has been intensified due to increases in other public infrastructure like utilities (telecommunications, water, gas, etc), water bodies and managed green-spaces. The translation and conversion effort to assimilate the spatial information was daunting, stumbled by myriad spatial formats (e.g. AutoCad files) and standards (e.g. coordinate systems)

With the rapid expansion of business needs and the advancement in Geographic Information System (GIS) technologies, LTA began to rationalise its GIS challenges and the demand for information services not limited by spatial and time barriers, but can occur anywhere, any time. The vision of a managed environment to foster collaboration among subject-matter experts and a more connected government in the sharing and exchanging of spatial information between agencies, served to provide the impetus for change in LTA.

# The Endeavouring Years in GIS

In 1999, a joint review team comprising both internal IT and user management staff, conducted an in-depth study of the existing Road Information Management System (RIMS). This effort led to the recommendation for an entire business processing re-engineering of the RIMS - a system with 12 sub-systems comprising 61 modules, supporting 12 user departments - in the management of the Development and Building Control function.

The study covered detailed review, analysis and diagnosis of existing processes, technology and tools assessments and streamlining of procedures based on the following set of criteria:

- criticality of functions
- simplification of procedures and processes
- reduce duplication through systems integration
- use of common standards & taxonomy

Through the review, new processes were established and workflow processes refined to improve business efficiency and integration. The RIMS required extensive re-development to incorporate these new and refined processes. Based on the analysis of the business processes derived from the BPR study, the proposed new system would require the following key components:

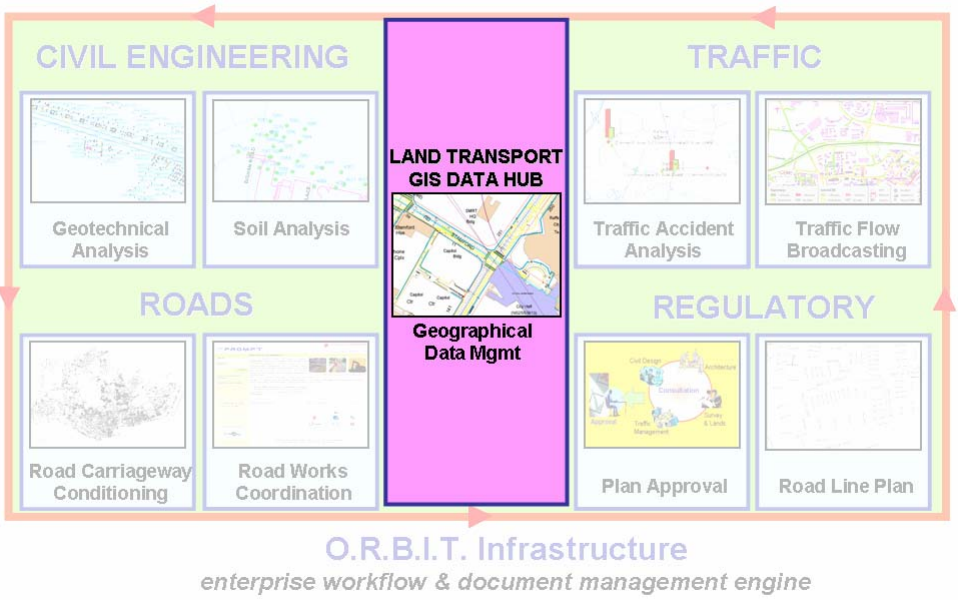
(a) Geographic Information Systems that provides a graphical representation and information of places where spatial statistical analysis can be carried out;

(b) Workflow Management System that manages business processes where tasks are processed, managed, monitored and routed;

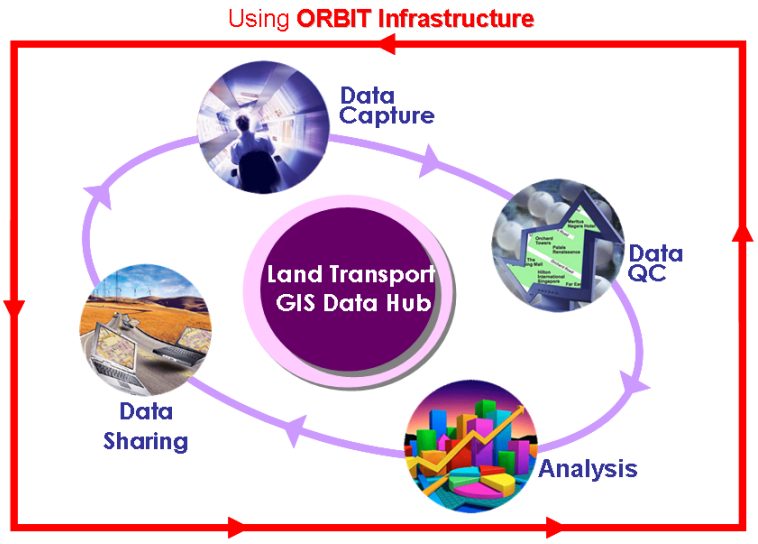
(c) Document Management System that manages documents by indexing and storing them with strict access control.

## Implementation Strategy

Firstly, an **outside-in approach** was adopted to identify the nerve centre of these myriad modules. Central to the business processes was a need for a common repository of geographical information. Hence, the Land Transport GIS Data Hub (LTGDH) was birthed to encapsulate the growing number of digital map layers, such as road safeguarding information (eg. Road and Tunnel Reserves, Road Land Polygons); road features information (eg. Kerb Lines, Network Lines), road inventory information (eg. traffic lights, bus-stops); and rapid transit system information (eg. RTS Lines, RTS Stations). To date, the LTGDH has more than 70 layers of GIS information and growing.

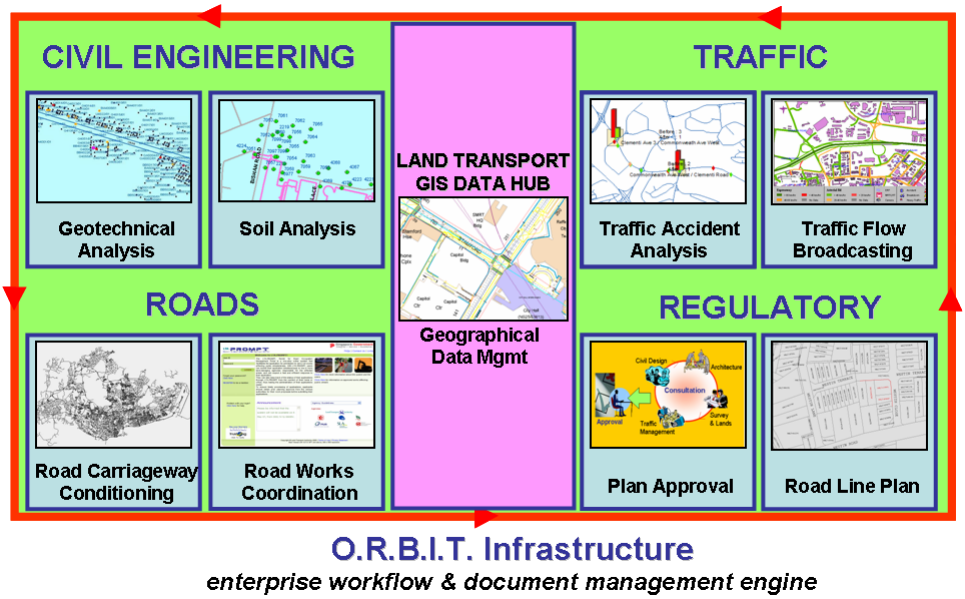



Besides the need for a central repository of GIS information as a single source of reference and retrieval, data governance was vital to establish clear accountability, ownership, access rights and version control. Data quality and accuracy is also ensured with centralised verification. To facilitate GIS information exchange within LTA and across government agencies, LTGDH adopted OpenGIS standard to support more than 10 GIS formats, and the National Coordinate System, known as Survey21, to standardise on a Singapore-wide location system with localised precision, as opposed to the international Cassini-Soldner Coordinate System.



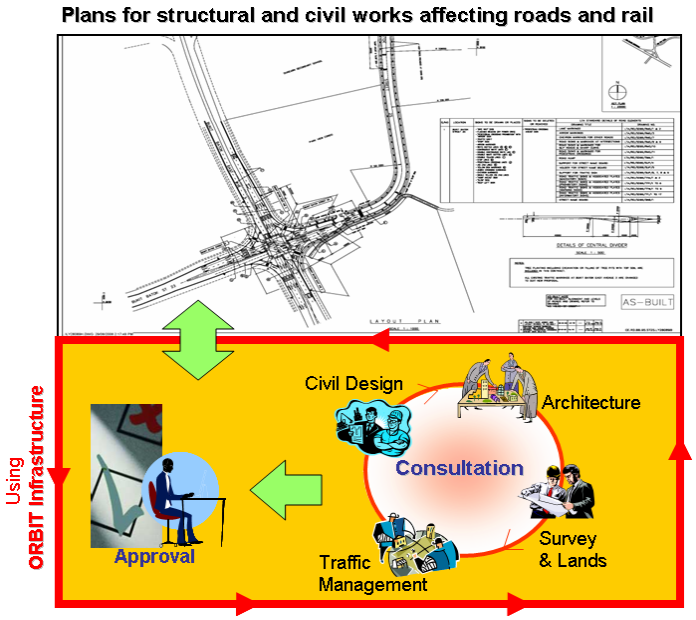

LTGDH also leverages on LTA's enterprise workflow and document management infrastructure – the One-stop Retrieval & Infobank Interchange (ORBIT) infrastructure – to enable knowledge-sharing and collaboration across business units.

With the foundation of LTGDH and ORBIT, we next extended the framework to other business applications through an **inside-out approach**.



## Regulatory Function

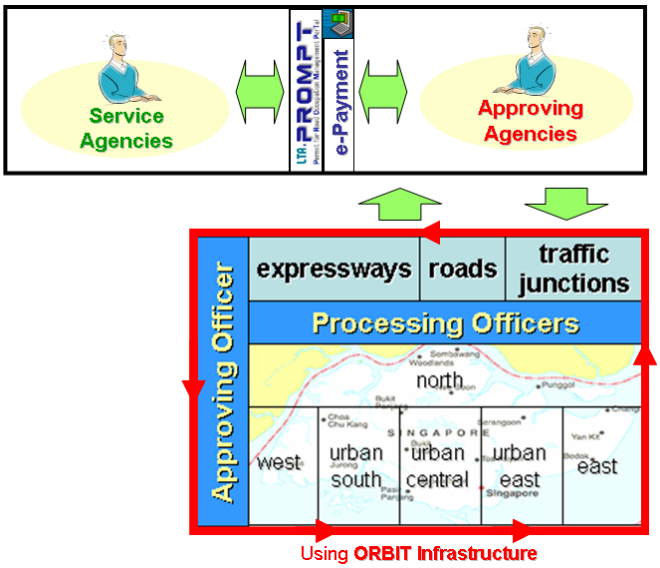
In the Regulatory domain, LTA regulates structural and civil works that may affect road and rapid transit system infrastructure as part of planning and development efforts. Through an online submission system, civil engineers and consultants submit their plans to LTA for endorsement. Online reviews among subject-matter experts through GIS maps support collaborative efforts to steer detrimental works away from our transport infrastructure.



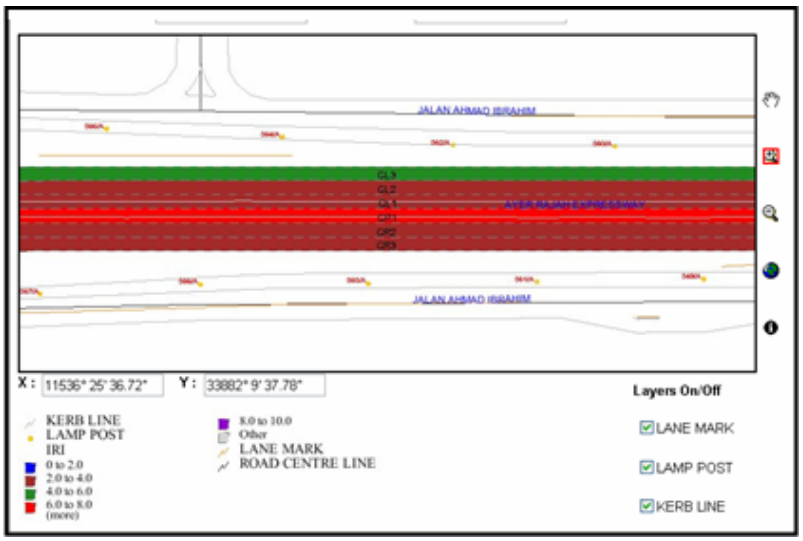

Another means of safeguarding our land transport infrastructure is the Road Line Plans and Railway Protection Plans. The Road Line Plans contain future road reserve alignments and widths based on various land use and transport studies, while the Railway Protection Plans consist of boundaries of the railway protection zone. Surveyors, real estate developers, lawyers, architects and engineers can purchase these plans online for reference when performing property transactions and drafting development proposals.

## Roads Management

In the Roads Management domain, LTA has spearheaded an inter-agency system to coordinate road works so as to minimize disruption to road users. Utility service agencies like telecommunication companies and utility providers who need to carry out works such as laying of power cables and gas pipes, on public streets or areas are required to apply for permits from the corresponding government land-managing agencies. Through a one-stop portal – LTA.PROMPT (Permit for Road Occupation Portal) – service agencies submit their application for the road works permit.

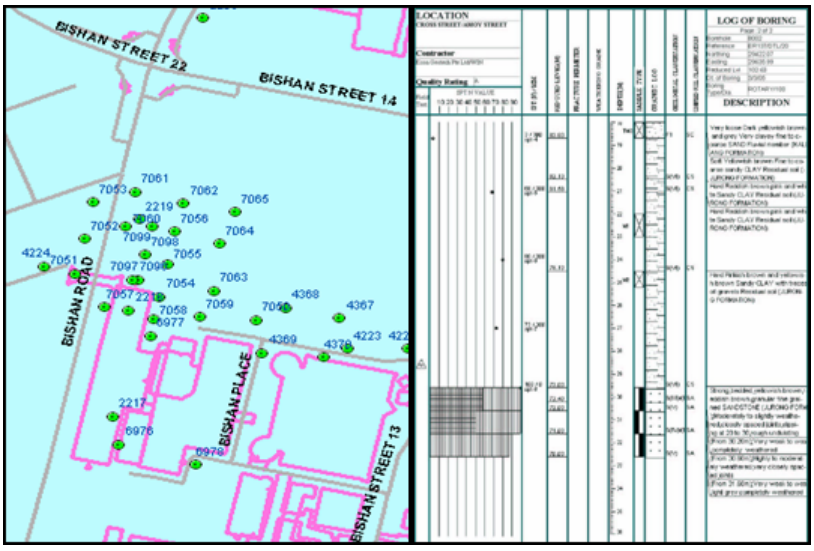



LTA also uses GIS technology to plan the maintenance regime for the road carriageways across Singapore. GIS maps help to visualise road carriageway conditions captured by specialised vehicles. The road conditions are maintained at an optimum level of roughness and skid resistance, minimal rate of deformation, and within an allocated budget. With predictive forecasts on road deterioration and structural life, road maintenance works are prioritised for different treatment methods accordingly while optimising the use of the budget.

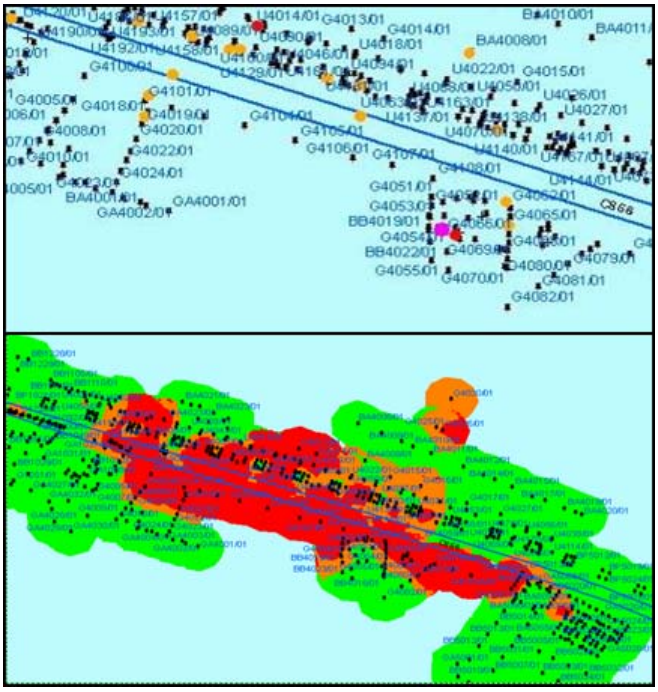



## Civil Engineering

LTA, being the main government agency for land transport developments in Singapore, has over the years in the course of building land transport infrastructure such as RTS lines and major expressway amassed a wealth of information pertaining to the soil structures surrounding the structural foundations of land transport infrastructure projects. The Civil Engineering domain utilises GIS technology to capture borehole information for soil analysis, planning of construction site excavation, foundation design and tunnel alignment. To date, there are more than 8,000 borehole records captured.



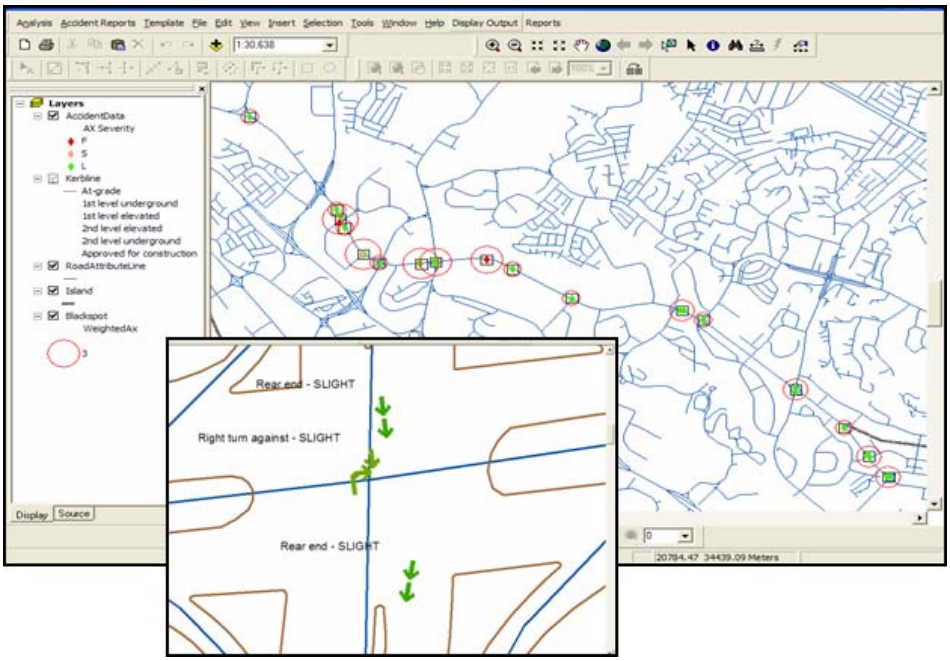
Maintaining a high level of safety in and around LTA worksites within urbanised areas is also of paramount importance, to observe and comply with the Factory Act and Fire Safety Act of Singapore. LTA has always placed emphasis on putting in place stringent measures to ensure that all staff, contractors and those living nearby are protected at all times. As safety is a primary objective of LTA in the planning, design, construction of land transport infrastructure, we have deploy GIS related technology to track the location of site instrumentation and monitoring of construction site instrumentation reading such as ground movement, ground water table, inclinometers as part of the pro-active measures in ensuring construction safety.



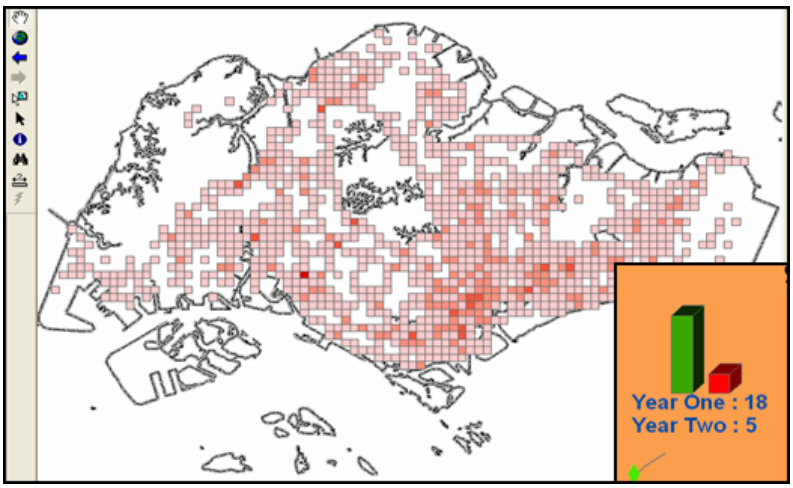
As part of a total safety management process to manage safety risks of infrastructure projects, major civil hazards are monitored and tracked across construction phases with the aid of GIS maps. Risk Management Facilitators at major project sites are required to identify potential safety hazards using a structured risk assessment framework and determine their corresponding mitigation measures. The progress of the mitigation measures put in place is followed through and monitored subsequent phase of construction.

## Traffic Management

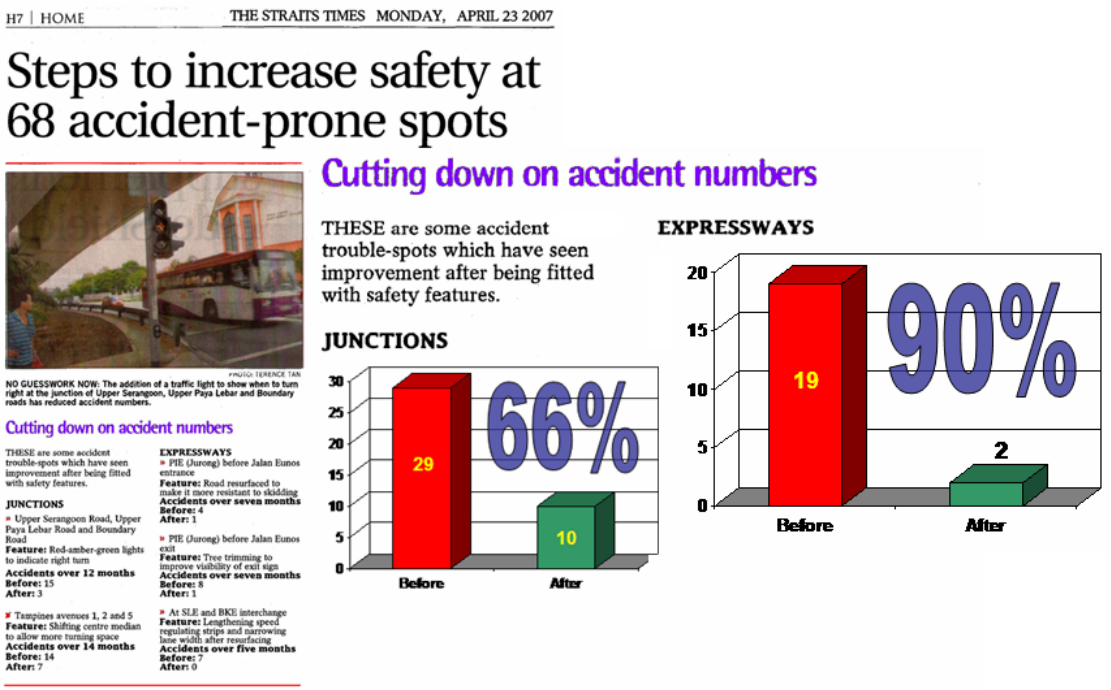
With the rapidly increasing vehicle population and the rising expectations of the traveling public, it is insufficient to merely provide better road network and a more efficient public transport system. LTA is also expected to provide a safer and more orderly motorized society. In the Traffic Management domain, LTA crystallized a multi-query accident-based application integrated with geographical analysis.




In the past, LTA has been limited by the use of only statistics, charts, and tabular information to analyze the traffic accident or collision patterns to assist in the identification of hazard locations in need of road safety improvement. This means a tedious task of looking at and manipulating the rows and columns of figures. It was realized that spatial visualization of these collision distributions or patterns could make a more visual impact as maps by nature are more intuitive than statistics, tables and even charts in understanding a spatial phenomenon.




Collaborating with the Singapore Traffic Police to capture traffic accident information, traffic accident analysis makes use black spot analysis and comparison grid analysis to identify accident-prone areas through geographical visualisations leveraging on GIS technology, study the traffic scheme in that area, and implement site treatments. This programme has yielded reduction in accidents over a 2-year period in many troubled areas. This project has won the prestigious **Prince Michael International Safety Award 2007** for outstanding achievements in its collaborative efforts in promoting road safety through innovations in engineering and active public education.



H7 | HOME THE STRAITS TIMES MONDAY, APRIL 23 2007

# Steps to increase safety at 68 accident-prone spots

PHOTO: TERENCE TAN

NO GUESSWORK NOW: The addition of a traffic light to show when to turn right at the junction of Upper Serangoon, Upper Paya Lebar and Boundary roads has reduced accident numbers.

## Cutting down on accident numbers

THESE are some accident trouble-spots which have seen improvement after being fitted with safety features.

**JUNCTIONS**

- Upper Serangoon Road, Upper Paya Lebar Road and Boundary Road
  **Feature:** Red-amber-green lights to indicate right turn
  **Accidents over 12 months**
  **Before:** 15
  **After:** 3

- Tampines avenues 1, 2 and 5
  **Feature:** Shifting centre median to allow more turning space
  **Accidents over 14 months**
  **Before:** 14
  **After:** 7

**EXPRESSWAYS**

- PIE (Jurong) before Jalan Eunos entrance
  **Feature:** Road resurfaced to make it more resistant to skidding
  **Accidents over seven months**
  **Before:** 4
  **After:** 1

- PIE (Jurong) before Jalan Eunos exit
  **Feature:** Tree trimming to improve visibility of exit sign
  **Accidents over seven months**
  **Before:** 8
  **After:** 1

- At SLE and BKE interchange
  **Feature:** Lengthening speed regulating strips and narrowing lane width after resurfacing
  **Accidents over five months**
  **Before:** 7
  **After:** 0

## Cutting down on accident numbers

THESE are some accident trouble-spots which have seen improvement after being fitted with safety features.

**JUNCTIONS**



**EXPRESSWAYS**

Other than ensuring road safety, LTA is also proactively disseminating traffic-related information through our One.Motoring portal, an integrated one-stop online site that house all motoring and road-related information in Singapore and vehicle-related transactional e-Services. Leveraging on Traffic.Smart, an intelligent traffic and incident management platform, LTA broadcasts average travelling speed on major arterial roads and expressways via an interactive GIS map. Accidents and road works are also indicated.


**About One.Motoring**

Launched in 2000, the ONE.MOTORING portal (www.onemotoring.com.sg) is an indispensable online destination for the motor trade industry, vehicle owners, and the general public in Singapore. With more than 8 million monthly page views, this comprehensive information, service and community portal polled user satisfaction ratings of 93% in 2008. It was also awarded the **2006 National Infocomm Award (Merit), Singapore** for the most innovative use of infocomm technology in the public sector, among a number of international accolades and a Winner of the **CIO Asia Award** in 2003.

# Benefits to Community

### 1. For Public – Safeguarding Public Safety

With regulatory functions, the structural integrity of land transport infrastructure is protected against any constructional intrusion so that community is safe using the roads and rapid transit systems. The geotechnical instrumentation monitoring coupled with GIS technology further ensure that the safety of all workers within LTA's construction sites as well as the community in the surrounding areas at all time by being proactive in monitoring and minimising ground movement to protect the integrity of structures and buildings in the vicinity. On the roads, motorists' and pedestrians' safety is also protected by reducing the number of traffic accidents at accident-prone areas using mitigating traffic schemes. As a result, traffic accidents are reduced at treated traffic junctions by 66% and expressways by 90%.

### 2. For Road Users – Smoother Travelling Experience

With a more efficient and effective coordination of road works, disruptions to traffic flow are minimised. Road carriageways are also proactively monitored to prevent possible skidding during wet weathers. Corrective maintenance is also in place to quickly resurface uneven road surfaces and localised sunken road spots caused by unexpected geological conditions. Another way to improve the travelling experience is to keep motorists abreast of average travelling speed of vehicles along major arterial roads and expressways. Motorists can plan their routes to side-step roads that are heavy-laden with traffic or affected by road works and accidents.

### 3. For Businesses – Being Pro-Enterprise

With a no-wrong-door policy, the LTA.PROMPT portal provides a convenient one-stop solution for applicants to seek approval for their road works from multiple government agencies at the same time without making a single trip to

the respective agencies affected. Applicants can query the status of their permit applications online anytime anywhere. With this portal, applications are processed within 2-3 weeks compared to 2-3 months previously. Plan approvals for civil and structural works have also improved from 21 days to 10 days. Civil engineers, consultants and private developers can also conveniently acquire Road Line Plans and Railway Protection Plans instantaneously online anytime anywhere compared to 10 days previously.

## Implementation Challenges

### 1. Changing Mindsets

As LTA was formed through the merger of 4 public entities, we inherited many legacy systems that function within individual department. Other than the need to refresh obsolete technology, we need to change mindsets to move the business users' paradigms from department-based systems to cross-functional systems to enterprise systems.

### 2. Managing Varying User Needs

Extensive business specific and business-unit specific processes had to be streamlined to reduce duplication and these were done in close consultation with process owners and key business users. Bringing together numerous interest groups and negotiating to streamline their processes without losing sight of their needs, was a mammoth task.

### 3. Lack of Standards and Governance Process

LTA has also inherited disparate data sets through the merger. They needed to be standardised to migrate into a single repository for consistent interpretation of the information. Moreover, the ownership of these data sets was unclear and lack accountability. Data governance had to be enforced to establish accountability and sanitise the data to maintain its quality and accuracy.

## The Future Years in GIS

Recently, the Ministry of Transport in conjunction with LTA completed a land transport review to map out Singapore's needs for land transport over the next 10-15 years. Our population has increased significantly in the intervening years and become more diverse. Responding to this trend, the Rapid Transit System (RTS) network will be doubled from 138km today to 278km so as to extend the reach of the RTS to many more people and places. Additional roads will be built to serve new developments and support economic growth as well. However, we face increasing constraints in road building as Singapore becomes more densely built up. GIS technology is the critical factor to more effective and efficient decisions on land use for constructing the land transport infrastructure.

Confronting a fast-paced development of land transport infrastructure and an extensive use of intelligent traffic management technologies, LTA's GIS framework needs to be more agile and nimble to respond to changing business needs. GIS will have to become a location-based service that business applications can easily fuse geospatial content with geocentric business processes and with other shared enterprise business services. With this geospatial service-oriented architecture, it will also be easier to enable business intelligence and analytics to extract strategic information across different business platforms to make effective and timely business decisions.