Managing Tomorrow’s Transportation System with GIS

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Agenda

• Transportation Professionals Increasingly Face Four Major Challenges:
  – Provide Comprehensive Information Systems that Effectively Guide Decision Making (Data and Systems Integration)
  – Maintain an Accurate Asset Inventory
  – Ensure the Safety of the Transportation Systems
  – Monitor the Effectiveness of Transportation Policies
Key Transportation Agency IT Issues

• Integration to Support Agency-Wide Business Functions:
  
  – Need to provide easy access to data and information: A seamless flow of information regardless of format, platform or location
  
  – Need to integrate data across the enterprise; to integrate data across the “project lifecycle”
  
  – Acquire Best of Breed COTS Solutions, and Have Them Seamlessly Integrated

Legacy apps are not integrated to enable agency-wide view
Challenge: How to make sense of the data and information?
Integration to Support Agency-Wide Business

• Why an Issue? Because Increasingly the Most Valuable Resource Within a DOT is the **Information Infrastructure**

  – 85 Percent of Data in Modern Organizations is **Unstructured** *
  
  – 30 Percent of People’s Time is **Spent Searching for Relevant Information** *
  
  – 60 Percent of CEOs and Agency Directors **Feel They Do Not Have the Type of Information Support to Make Good Decisions** *
  
  – 90 Percent of Information in a DOT has a Spatial Component

* Source: IBM

GIS as the integration platform
Smooth Information Flow?

ESRI software supports many disciplines across the entire transportation enterprise.
Integration Issues

• Data is located at the application level, often in different formats: “Islands of Data”

• Distributed and Heterogeneous Environments: Different OS, RDBMS, Hardware Platforms

• Major Gaps in Information Flow across the Agency

• Desire to Have Technology Support Business Processes, Rather Than “Drive Them”
Obtaining Value from Enterprise Programs

• Goal is to provide a long lasting technical architecture that meets business needs and efficiently leverages COTS technology.
• Matching technology capabilities to business needs.

An iterative process; maturity takes time!
Integration Frameworks
Integration to Support Agency-Wide Business

• Approaches to Enterprise Application Integration (EAI):
  – Point to Point APIs
  – Data integration / Data Warehousing: through use of ETL tools, creation of a common DBMS
  – Web Services
  – Service Oriented Architecture: integrating Business processes through Message Buses (Enterprise Services Buses)
Point-to-Point APIs

Can produce a lot of overhead when multiplied
Data Warehousing

- Capital Programming
- Projects
- Construction
- Environmental
- Right of Way
- Crash Data
- Traffic Volumes
- Assets
- Pavement

GIS

Data Warehouse
Services Oriented Architecture

• Allows you to build applications, drawing data and logic from different existing sources, and combine them in ways that meet your current business requirements

• A flexible and agile integration framework; technology and platform independent

• Reflects IT Best Practice: “By 2008, SOA will be a prevailing software engineering practice” (Gartner)
Case Study
Georgia Department of Transportation (GDOT)
GDOT Background

- Mature DOT: First Implemented GIS in 1993
- One of Two Agencies Selected for Testing of ArcGIS 9.2 (GDOT and FedEx)
- Use of Server Technology – Ability to Integrate Multiple Services
- Agile Development Approach
- GIS and IT are Together
- Migration of Existing Application to SOA Architecture
TREX Internal Database Integration

- Transportation Project Data (Tpro)
- Construction Data (Tr*nsPort)
- Bridge Data (BIMS)
- Facilities Data (FleetAnywhere)
- Crash Data (AIS)
- ITS Data (Navigator)
- Traffic Interruptions (TIR)
- Roadway Images (Videolog)
- Permits Data (AMPS)
- Roadway Characteristics (RC)
- Financial Data (PeopleSoft)

Existing RDBMS:
- Oracle
- SQL Server
- Sybase
Basic Interface
Wizard

Wizard delegates rendering to datasource specific SearchRenderer

Supported trexFormElt:
- LOV
- STATIC-LOV
- STATIC-LOV (staticLovProjectsStipCodes)
- LOV,STATIC-LOV (staticLovProjectsStipCodes)
- STATIC-LOV,STATIC-LOV (staticLovStatus , staticLovProjectsStipCodes)

ProjectSearchRenderer  AADTSeararchRenderer  LegislatorsOfficialsSearchRenderer  CrashSearchRenderer
Query Builder
TREX Data Integration

- Photos
- Video/Photolog
- Scanned Files
  - Concept Reports
  - Design Plans
  - ROW Plans
  - Archived Plans
Reports

- Preconstruction Status Report
- TRIM Supplemental Reporting
Improved Functionality

ArcWeb Services Integration

Geoprocessing

Better Results Management

Ease of Integration

Advanced Search Framework
External Data Integration

- ESRI ArcWeb Services
  - Address Finder
  - Weather Data
    - Current
    - Forecast
    - Precipitation
Architecture

- ArcIMS-ArcGIS Server
- SOAP/XML Web Services
- ArcWeb Services
- Java 9.2 Pre-release ADF
- AJAX (Asynchronous JavaScript and XML)
GDOT Success Factors

- Framework Development Established the Standards for Subsequent Development
- Agile Development Methods
- Technology Transfer: Co-Development and Cross Training
- Good Technical Skills
- Easy to Add and Swap Out Components
Core Technologies
Support Better Decision Making
Enterprise Implementation

• Four core technologies which are central to a Transportation IT Architecture:
  – ERP: Financials and HR systems
  – Electronic Content Management Systems
  – GIS
  – RDBMS

• To support the Enterprise, these systems should be integrated
ERP Integration

Why?:

- Project Management and Tracking
- Consistent Project Financials through Planning, Design, Construction, Operations and Maintenance: capture full life cycle costs of projects
- Integrated Maintenance and Work Order Management
- Asset Inventory
- Linkage to HR Systems
Construction and Project Management

Rhode Island DOT
Asset Maintenance with Maximo

Pending Service and Repairs
- Air
- Animal Control
- Communications
- Electric
- Gas
- Municipal Information Systems
- Reclaimed Water
- Storm
- Water
- Waste Water
Project and Construction Management
Project Support from Start to Finish

- Modern Infrastructure Projects are Complex Multi-Year Projects which require careful monitoring, coordination, and management
- Require access to large amounts of data and information in real-time

Australia’s Eastlink Project
Case Study
City of El Paso, Texas
Street Assets

• Maintains
  – All city roads (Pavement)
  – Alleys
  – Bridges
  – Ditches
  – Drainage and Manholes
  – Medians
  – Traffic Signals
  – Signs
  – School Flashers
  – Crosswalks
  – Lanes
  – Street Striping
  – Parking Meters
  – Street Lights
  – Sidewalks
Legacy Asset and Work Order Management

- DOS based desktop system
- No cost tracking ability
- Asset database did not exist
- GIS use was limited
- Paper backlog
- Homegrown pavement management system
1. Pavement/Asset Survey

2. To Cityworks/MicroPaver

3. Condition Rating and Priority Repairs
Method

- High resolution cameras (1600x1200)
- Robust positioning (highest accuracy GPS/INS commercially available)
- LiDAR (automated asset detection)
<table>
<thead>
<tr>
<th>Feature</th>
<th>Count</th>
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<tbody>
<tr>
<td>Bridges</td>
<td>177</td>
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<tr>
<td>Traffic Signs</td>
<td>86,575</td>
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<tr>
<td>Intersections</td>
<td>13,904</td>
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<tr>
<td>Pedestrian Crossings</td>
<td>1,475</td>
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<tr>
<td>Poles (Ped/Signal)</td>
<td>505 / 1,557</td>
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<td>ADA Ramps</td>
<td>14,155</td>
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<td>27,067</td>
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<tr>
<td>Speed Humps</td>
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<tr>
<td>Pavement Legends</td>
<td>13,626</td>
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<tr>
<td>RR Crossings</td>
<td>200</td>
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<tr>
<td>Storm Inlets</td>
<td>21,467</td>
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</table>

**Total Features**: 386,529
Linear Infrastructure

**Linear Features**

- Curbs: 2,223
- Dividers: 151
- Guardrails: 28
- Number of Lanes: 6141
- One Way Streets: 71
- Pavement Markings: 3,655
- Road Width (area): 38,844,698
- School Zones: 31
- Shoulders: 3,222
- Sidewalks: 1,874
- Sidewalk Handrails: 9
- Speed Limit Zone: 2,798

**Total Linear Features**: 20,203
El Paso Benefits

- Allows performance to be measured
- Improved customer service
- Improved efficiency
- **Better justification for funding**
- **Better decision making**
- Accountability
- Centerline enhancements
- Image Playback for site inspection
Enterprise Content Management Systems (ECMS) Integration

• Why?:

Disparate information management technologies have arisen that cope with the special characteristics of different types of data.

• DBMS for structured, tabular data
• ECM for unstructured documents and files
• GIS for spatial information
Goal is to Remove Barriers between Information Technologies
Why Integrate?

So that users are not burdened by the fact that some of the information or functionality they might need is in one system while the rest is somewhere else.

“A seamless flow of information regardless of format, platform or location”
Highway plan related to route via measures
GIS in the Project Life-Cycle

Begin with GIS at early stages...
Enterprise GIS Products and Tools

• Making the Case for an Enterprise GIS, and the Integration of the Core Technologies

• How does ESRI help you achieve this Goal?:
  – Enterprise Software Products
  – Common Component Architecture
  – IT Standards Based
  – Interoperability
  – Established Relationships with More Leading IT Companies than Anyone else
  – Continuous Research and Product Development
  – Commitment to our Customers’ Success
Linear Referencing Systems
Linear Referencing and Management

- **LRS = Linear Referencing System**
  - a set of procedures and methods for specifying a location as a distance, or offset, along a linear feature, from a point with known location.

- **LRM = Linear Referencing Method**
  - part of a LRS. Different methods of measuring location.

- **Dynamic Segmentation (Dyn Seg)**
  - line features don’t have to be split (i.e.; "segmented") each time an attribute value changes -- you can "dynamically" locate the segment.
There are several different ways to integrate data from multiple LRMIs – Your Business Requirements will determine how you want to handle.

ESRI gives you a rich set of tools to satisfy your enterprise data and spatial management requirements.
Linear Referencing Tools

• Create routes
  – Create and calibrate routes.
  – Convert existing routes.

• Route display and query
  – Find route locations.
  – Identify route locations.
  – Hatching.
  – Route measure anomalies.

• Event display and query
  – ‘Dynamic Segmentation’
    • Event matching statistics.
    • Locating angles.

• Event Geoprocessing
  – Overlay events.
  – Event transform.
  – Dissolve/Concatenate events.
  – Locate features along routes.

• Editing routes in ArcMap
  – Route creation.
  – Edit tasks.
  – Measure editing tools.
LRS Example #1

Straight Line Diagram
LRS Example #2

Dual-Single LRS
HPMS Reporting

• Provide data that reflects the extent, condition, performance, use, and operating characteristics of the Nation’s highways

2010 HPMS

• Improve HPMS to support customer business needs
• Improve data quality, collection and reporting
• Maximize use of existing, future and other data sources
• Enhance value of information to providers and customers
• Promote effective use of changing technologies
• Spatial submittal
GIS in Safety Management Systems
Real Time Control Rooms Are Becoming Spatially Enabled
Map+Detail page. Clicking on an incident symbol displays the incident details.

All Information is logged in the database

California Highway Patrol...3,000 daily in LA
GIS in Roadway Safety Systems
Traveler’s Advisories
Evacuation Systems
GIS in Safety Management Systems
Custom ArcGIS Server Analysis

Show Me the Top 25 Crash Locations
Case Study

New York State
NYS - ALIS
Accident Location Information System

Web-based Accident Management System
NYS ALIS
Accident Location Information System

Project/Stakeholders
- Multi-year/Multi Agency Project
- NYS DMV/DOT/CSCIC
- MPO’s, Cities, Counties, Indian Reservations

Technology - 5 ArcGIS Server Web applications
- Location Coding Data Entry (LCDE)
- Location Editing / Simple Query & Report (LESQR)
- Map Maintenance Notification & Tracking (MMNT)
- Street Name Editor (SNE)
- Query Reporting & Analysis (QRA)

Data
- 12+ million Accident records
- NYS Data Product
Establish New High Accuracy Statewide Basemap
- Reduce Duplication of Mapping Initiatives
- Share Common Road Network
  - State & Federal Agencies
  - Local Agencies
  - Citizens
Centralize Data Maintenance & Standards

Custom Accident Location Applications
- Vastly Improve Efficiency and Accident Location Coding and Editing
- Provide Basic Query and Reporting Tools
- Meet Consumer Information Requests
- Sophisticated Accident Analysis (QRA)
- Web-Based Executive System for Decision-Makers

DataSets
- Up-to-date street centerlines
- Street names, route numbers & aliases
- Address ranges & address point layer
- NYSDOT Linear Referencing Systems
- Thruway Authority Linear Referencing Systems
- Railroads/Bridges
- Civil & public land boundaries
- Census geography/Zip Code boundaries
- Landmark features
- Hydrography

Location Coding Methods
- Field Coordinates
- On street/cross street Intersection
- On Street /Bridge Intersection
- On Street /Railroad Intersection
- Address Match
- Reference Marker
- Milepost
- Landmark
- Municipality/county
An Accident’s Path through ALIS

Collision Occurs

Police Agency
Records Accident Details

ArcGIS
Server

NYSDMV Records
Accident Data in AIS

ArcSDE

CSCIC Provide GIS
Map Updates
MMNT & SNE

NYSDOT Safety Info Management
Systems Receives Data

Intranet

NYSDOTQRA
Accident Analysis

NYS Accident Location
Information System

SIMS

NYSDOT LESQR
Query/Reports

Accident Analysis
Accident Prevention Strategies

Strategies

NYSDOTQRA
Query/Reports
Accident Location Information System | Location Coding Data Entry | MV104 Location Entry Form

Accident Case: 31521635

County: Schenectady
Muni: Rotterdam (T)

On Street: GUILDERLAND AVE

Cross Street: DRAPER AVE

At Intersection
Parking lot
Non-Highway

Distance: 300 FT

Reference Marker: 29 180 41012

Milepost: House Number

Nearest Landmark

DISCUSSIONS not available on http://transerver.esri.com/
MV104 Location Entry Form

Case: 6720850  
NCIC: 13601  

County: (None)  
Municipality:  

Reference Marker: 14563728  
Milepost: 13.2  
On Street/Route: BATES RD  
Cross Street/Route: PORTAGE RD  

Distance: 0.05  
North From Cross Street  

Nearest Bridge:  
Nearest Landmark: LockThruway  

Non-Highway Parking Lot  

Accident related comments  

Location Candidate 1  
Location Candidate 2  

Send to Supervisor  
Process
QRA Application Specifics

Identify High Accident Locations (HALS)
Identify Concentrations of Specific Accident Types
Conduct Detailed Accident Analysis
  • Spot/Intersection/Bridges
  • Strip
  • Sliding Scale
  • Corridor
  • Attribute

Produce Reports illustrating Tabular Analysis Results
Provides Query Capabilities against Accident Data
Query Reporting Analysis (QRA)

Accident Analysis Results Supports
- Accident Mitigation Practices
- Road Improvement Projects
- Safety Policies and Procedures
- Funding for Capital Improvement Projects
- Increased Law Enforcement
- Post-Implementation Evaluation System (PIES)
  - Review Recommended Improvement Impact

QRA Stakeholders
- NYS DOT
- Local Governments & Metropolitan Planning Organizations (MPO)
QRA Filters
Spot Analysis
Performance Monitoring
Performance Monitoring

• Need to Demonstrate the Effectiveness of our Transportation Investments

• Need to be able to Make Effective Trade-Offs in Investments

• Need to Monitor Performance
Performance Monitoring

• ITS Technologies are Capable of Generating Voluminous Data, but Much of that Data is Not Utilized
  – Embedded Loop Detectors
  – Motion (Speed) Cameras
  – Real Time Probe Data

• ITS Data can be mined for Performance Monitoring, and Planning Activities
MD iMap, Public Viewer Stat Data from Green Print
Traffic Conditions

Generic diagrams for any data

Visualization of traffic state

Journal component
Executive Dashboard Systems

[Image of a dashboard interface with various performance metrics and icons for Virginia Department of Transportation (VDOT)]
Case Study
Pennsylvania Turnpike Commission
The PTC EIS: A True Geospatial Information Management System

W.E.C. Engineers, Inc.
Bridgeville, Pa

PTC’s Readiness for an Integrated Decision Making Enterprise
Performance Management

• Performance metrics are **measurements that act as tools to influence decisions** and drive behavior.
• Measurements are used to **focus the organization and drive success** by developing strategies that influence positive change on the measurement.
• Measurements **lead management teams and employees to focus on value-added efforts** and drive continuous improvements.
• **What is the role of a Metric?**
  – Barometers for organizational or process health
  – Typically evaluated over longer time periods
  – Trended for performance comparison

• **What is not the role of a Metric?**
  – Not targeted to solve day-to-day execution problems
  – Not to replace transactional data systems
  – Not to replace ad-hoc system queries
Types and Number of Metrics

- 12 Enterprise Metrics

- 30 Core Processes Metrics
  - 12 for Roadway Operations
  - 7 for Roadway Maintenance
  - 11 for Roadway Construction

- 56 Shared Services Metrics
EZ Pass Statistics
Fare Collection per District
Filter by Layer Groups
Filter by Features and Events
Conclusion

• Integration to Support Agency-Wide Business Functions:

  – Need to provide easy access to data and information: “A seamless flow of information regardless of format, platform or location”

  – Need to integrate data across the enterprise; to integrate the “project lifecycle”

GIS enables Transportation Agency-wide Integration