GIS Applications and Integration on Transportation Planning and Design Projects

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Agenda

• GIS/CAD Integration Discussion
• Integration Solutions
  • different levels of integration for individual needs
• Evaluating your Organization’s Needs
Transportation Planning

- GIS to support the Transportation Planning Process
  - Alternative Design Screening and Development
  - Environmental Impact Statement (EIS)
  - Design/Build Projects
  - GIS/Survey Integration
Past State of GIS on Transportation Projects

• Many times on Transportation projects GIS is an after thought
  • CAD was typically used to calculate environmental impacts
  • GIS was brought in at the end of a project to create maps to be included in the final report
  • multiple datasets, different standards, different versions
Current and Future State of GIS

- Entrenched in the planning process
  - Included at the scoping phase of the project to help assess the level of effort
  - Analysis is performed in GIS
  - Create working maps for project team(s)
  - Create presentation material for community outreach
  - Create most of the maps for the final reports
- Getting more involved at the Alternative Design and Design/Build phases
  - Preliminary impacts for alternative screening process
  - GIS/Survey integration
Need for Integration

• We are information junkies
  • Want to know where things are as well as the details about them
• We want the most accurate data possible for the least amount of money
  • If you had accurate (6-in) roadway centerline or survey-grade parcel boundaries wouldn't you want that in GIS?
• End user typically doesn’t care about the technology just what the end results area
  • We don’t want to go to different applications for different information
    • increase use in Portals, Dashboards, etc…
Value of Managing Data

CAD Drawings

In-field info captured

Critical infrastructure and asset information converted in asset management system

Maintain integrity

Transfer CAD Drawings to Construction Drawings (hard copy)

As-built drawings are transferred from scanning, re-digitizing into new system

Asset Lifecycle Stage

High

Low

Data Quality

Design

Build

Operate

Maintain

Intelligent Infrastructure for a Sustainable Future
Why is Integration so hard?

- CAD and GIS software evolved independently but parallel over last 30 years
- At their core CAD and GIS are different but complementary
- Both deal with geometry but they differ in size, storage, analysis, semantics, and attributes
- Different data models for different purposes
- Perception about accuracy of GIS data
- Perception CAD can’t manage attributes
- Lack of metadata or confidence in the data
Integration Solutions

• CAD and GIS data can come together
• Varying levels of integration depending on your business needs:
  • Import/Export or Direct Read
  • Extract, Translate, Load (ETL) Process
  • Application Interoperability
  • Shared Enterprise Databases
Levels of Sophistication

- Import/Export
- Direct Read
- ETL Process
- Application Interoperability
- Shared Enterprise Databases
Stage 1 - Import/Export or Direct Read

Simplest way to exchange data
file is sent from one user to another and each user must manually import the file
Exchange of Static Data
Conversion effort has varying levels depending on the quality of the data

Benefits
Good for one time file exchange
Quick, don’t need a database already setup for the data exchange
Import/Export functionality in software is getting better and better – can read information from multiple formats and give out data in different formats

Disadvantages
Data is Static – No link between the two systems
If data is changed in one system, then it has to be exported again
Time consuming for data that is exchanged regularly
Does not enforce any data design standards between the users
Conversion can be time consuming and process can change each time
Transportation Environmental Impact Statement

Stage 1 - Import/Export or Direct Read

- Direct Access to design files
- Import key elements of the design into GIS when necessary
  - usually when we need to add attributes or convert lines to polygons for analysis
- Export GIS to design team
  - they typically need parcels and environmental constraints
Alternative Screening – Sound Transit East Link

Ability to assess and narrow down list of alternatives at 2% design level in short time period

Characteristics:

- 5-month study
- 11-mile corridor
- 4 cycles of evaluations
- 19 evaluation criteria
- 10< subcontractors
- 28 route alternatives
- 24 proposed stations
Alternative Screening – Sound Transit East Link
# Alternative Screening – Sound Transit East Link

## EAST LINK ALTERNATIVE COMPARISON EVALUATION RESULTS

<table>
<thead>
<tr>
<th>Route Description</th>
<th>Transportation Goal: Improve Mobility</th>
<th>Environmental Goal: Preserve Environmental Quality</th>
<th>Land Use Goal: Minimize Risk</th>
<th>Implementation Goal: Provide a Financially Feasible Solution</th>
<th>Financially Feasible: (Delta to the Lowest) Cost</th>
<th>O&amp;M Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Segment B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1 - Bellevue Way</td>
<td>Rideship: 34,500</td>
<td>Travel Time (Minutes): 6.0</td>
<td>Lower</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>B2-A - Bellevue Way/112th SE</td>
<td>Rideship: 34,500</td>
<td>Travel Time (Minutes): 6.1</td>
<td>Slightly Higher</td>
<td>Higher</td>
<td>Slightly Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>B2-E - Bellevue Way/112th SE</td>
<td>Rideship: 34,500</td>
<td>Travel Time (Minutes): 6.0</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>Slightly Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>B3 - Bellevue Way/I-405</td>
<td>Rideship: 35,000</td>
<td>Travel Time (Minutes): 7.0</td>
<td>Slightly Higher</td>
<td>Higher</td>
<td>Lower</td>
<td>Average</td>
</tr>
<tr>
<td>B4 - 118th SE/I-12th SE</td>
<td>Rideship: 31,000</td>
<td>Travel Time (Minutes): 5.6</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>Slightly Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>B5 - 118th SE/I-405</td>
<td>Rideship: 31,000</td>
<td>Travel Time (Minutes): 8.6</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>Slightly Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>B6 - BNSF/I-12th SE</td>
<td>Rideship: 31,000</td>
<td>Travel Time (Minutes): 8.6</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>Slightly Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>B7 - BNSF/I-405</td>
<td>Rideship: 33,000</td>
<td>Travel Time (Minutes): 8.4</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>Slightly Higher</td>
<td>Higher</td>
</tr>
<tr>
<td><strong>Segment C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C1 - T - Bellevue Way/NE 8th - Tunnel</td>
<td>Rideship: 35,000</td>
<td>Travel Time (Minutes): 3.1</td>
<td>Higher</td>
<td>Lower</td>
<td>None</td>
<td>Slightly Lower</td>
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<tr>
<td>C2 - T - 106th NE - Tunnel</td>
<td>Rideship: 34,500</td>
<td>Travel Time (Minutes): 4.1</td>
<td>Lower</td>
<td>Higher</td>
<td>Slightly Higher</td>
<td>Slightly Lower</td>
</tr>
<tr>
<td>C3 - T - 108th NE - Tunnel</td>
<td>Rideship: 34,500</td>
<td>Travel Time (Minutes): 4.2</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
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<tr>
<td>C4 - A - 108th/110th Couplet</td>
<td>Rideship: 34,000</td>
<td>Travel Time (Minutes): 4.8/4.4</td>
<td>Higher</td>
<td>Slightly Higher</td>
<td>None</td>
<td>Higher</td>
</tr>
<tr>
<td>C5 - E - 110th NE - Elevated (Not recommended for further analysis)</td>
<td>Rideship: 34,000</td>
<td>Travel Time (Minutes): 2.8</td>
<td>Lower</td>
<td>None</td>
<td>Slightly Lower</td>
<td>None</td>
</tr>
<tr>
<td>C6 - A - 110th NE - At-grade/Elevated (Not recommended for further analysis)</td>
<td>Rideship: 34,000</td>
<td>Travel Time (Minutes): 3.9</td>
<td>Lower</td>
<td>Slightly Lower</td>
<td>None</td>
<td>Slightly Lower</td>
</tr>
<tr>
<td>C7 - E - 112th NE - Elevated</td>
<td>Rideship: 32,000</td>
<td>Travel Time (Minutes): 2.6</td>
<td>Higher</td>
<td>None</td>
<td>Slightly Higher</td>
<td>None</td>
</tr>
<tr>
<td>C8-E - 110th NE Elevated</td>
<td>Rideship: 34,000</td>
<td>Travel Time (Minutes): –</td>
<td>Slightly Higher</td>
<td>None</td>
<td>Higher</td>
<td>None</td>
</tr>
</tbody>
</table>

NOTE: RANKINGS ARE COMPARATIVE TO THE AVERAGE IMPACT WITHIN THAT SEGMENT FOR THE SPECIFIC RESOURCE EVALUATED. AVERAGES ARE NOT THE SAME FOR EACH SEGMENT.
**Stage 2 - ETL**

**ETL: Extract, Transform, Load**

Extracting data from outside sources,
Transforming it to fit business needs, and ultimately
Loading it into the data warehouse.

Link between data can be *Dynamic*

Established process for loading data into a database
First Component for next stages

**Benefits**
Makes data loads automatic and fast
Forces data to be consistent with design
Saves time (time = money) with each successive upload

**Disadvantages**
Requires more upfront planning

the design of the data on both sides needs to be determined, the scalability across the lifetime of its usage needs to be established during analysis.

Requires more advance user, more training
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

• GIS-Centric EIS
  • Supporting the Alternative Screening process
  • Development of Affected Environment Figures
  • Clear and Concise Representation of Design Alternatives
  • Environmental Impact Analysis
  • Maps for Client and Public Meetings
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

Project Background

• Multi-modal transportation project to improve mobility across Lake Washington
  • 13 mile corridor between Seattle and Bellevue
    • Affected cities include: Seattle, Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, and Bellevue
  • Alternatives initially considered included, No-Build, 4-Lane and 6-Lane options to replace the substandard highway and floating bridge
    • Later in the project 8 modifications to the 6-Lane alternative were evaluated
  • GIS has played a central role in the project
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

• GIS Tasks/Activities
  • Data Collection and Conversion
  • Base Mapping
  • Data Dissemination and Reporting
  • Environmental Impact Analysis
  • Ongoing Communication to Public through the Build process
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

Affected Environment Mapping
Environmental Impact Statement –
SR 520 Bridge Replacement and HOV Project

Design Alternative Mapping

Intelligent Infrastructure for a Sustainable Future
Environmental Impact Statement –
SR 520 Bridge Replacement and HOV Project

Design Alternative Mapping

Exhibit 11. Existing and Proposed Trails in McCurdy Park, East Montlake Park, and Washington Park Arboretum
SR 520 Bridge Replacement and HOV Project
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

• Environmental Impact Analysis
  • Standardized database allows for building model for repeatable processes
  • Run environmental impacts in a batch process
    • multiple resources (i.e. wetlands, parks, etc.)
    • multiple design alternatives
  • Allows for quick decision-making and alternative screening
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project
Impact Analysis
Communication to Project Team

- Alternatives and Impacts
- Document and GIS Portal
Data Dissemination

Communication to Stakeholders

- DOT, Cities, other Transit or Transportation Organizations
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

Communication to Decision Makers

- Governor and State Representatives
Environmental Impact Statement – SR 520 Bridge Replacement and HOV Project

Communication with the Public

- EIS Document
- Community Presentations
- Website
- Public Outreach
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Spatial ETL by Safe Software
ETL Workbench
Tacoma/Pierce County HOV Program

Stage 2 - ETL

Data Flow Options:
1. Data created in GIS and translated to CAD (DWG) and stored in ProjectWise.
2. Data created by Survey or Design and translated to GIS format and stored in GIS database.
3. Survey collects and processes data and transfers to GIS to be uploaded into the GIS database, then translated to CAD and stored in ProjectWise.

*Data flow is determined on a layer-by-layer basis and is documented in the data stewardship matrix.*
Engineering/Design – Tacama/Pierce County HOV Program
Engineering/Design – Tacoma/Pierce County HOV Program

• GIS Activities
  • Data Compilation between Design and Environmental
  • Interactive GIS Website
  • Environmental Documentation and Permitting
  • Geotechnical
    • boring planning, permits for drilling
  • Traffic
    • detour and traffic volume maps
• Design Team Support
  • land ownership, design impact analysis, construction sequencing maps, right of entry permits,
• Internal and Stakeholder Meetings
  • Tribe, Cities, Counties, Federal Agencies
Engineering/Design – Tacoma/Pierce County HOV Program

Geotechnical Boring Permitting
Design/Build – Tacoma/Pierce County HOV Program

Right of Entry Permits

Tacoma Railway
Notes: Coordinate with Jerry Chew 4 weeks before access into railway yard. Must have RR training and certification.
Status: WSDOT approved.
Right of Entry from Concorde Corp., City of Tacoma on 07/16/2008
Permit window: Unclear

Union Pacific Railroad (4713132669)
Notes: Coordinate with Jerry Chew 4 weeks before access into railway yard. Must have RR training and certification.
Status: ROE signed by Heritage and returned to Jim Zabel. Jim setting for BNSF to approve ROE before starting 30 day work.
Permit Window: When UP/RR signs Heritage will have 90 days. ROE for CHEM is approved and valid until 04/05.

BNSF Railroad (4713132300)
Notes: Coordinate with Jerry Chew 2 weeks before access into railway yard. Must have RR training and certification.
Status: BNSF approved 12/24/2002
Permit Window: 8/14/2007 - 8/14/2008

United States Corps of Engineers (Including west side of river - no parcel # available)
Notes: Coordinate access, one Parcel 3 weeks before access onto property. Due to access Charles Rd. (COR at 2007-164-358)
NO DRILLING OR DIGGING
Status for Topographical Survey and Environmental Review:

Status for Right of Way:
Topographic survey, SUE etc. Review for ROA Agreement for Geotechnical and BLFF work
Top comments to WSDOT. Waiting for determination that ROA is consistent with the CDEA requirements.

Payutuk Tribe of Indians (0326112014)
Notes: Coordinate with Mike Paul 2 weeks before access into property.
Status: John Davis, Payutuk Tribe of Indians signed the agreement 9/15/2008.

Puget Sound Transit (0326112035)
Notes: Coordinate with Jim Zabel. Jim setting for BNSF to approve ROE before starting 30 day work.

Union Carbide (0326112035)
Notes: Contact Cor to RES for ROE approval. ROE for RES on 1/14/2008

Source: Pierce County (2007) GIS Data (Routes, County Boundaries, Water Bodies). Vertical datum for all layers is NAD83(95), vertical datum for layers is NAVD88.
Design/Build – Tacoma/Pierce County HOV Program

Noise Mitigation

Source: Pierce County (2007) GIS Data (Zoning, Streets, County Boundaries, Water Bodies).

EXHIBIT X
Text Parcels within 500' Buffer of Fife Noise Wall #2
Tacoma/Pierce County Boundary
Washington State Department of Transportation
Engineering/Design – Tacoma/Pierce County HOV Program

Tribal Relations
Applications are used to draw from multiple data sets
Any user of the applications will have a view of the data sets

**Benefits**
Often use ETL procedures to upload data, making data consistent
Doesn’t require individual users to convert the data

**Disadvantages**
Potentially difficult and costly to maintain
Applications and databases must be “open” and non-proprietary
Only link between data sets resides in the application
Change in data sets can “break” the applications
Project Management Information System

Stage 3 - Application Interoperability

One portal or view point into multiple systems
Design Value
Time Component

Right-click to Visualize a Task in 3D

Timeline is synchronized with Portal Gantt Chart

3D Model of Construction Progress: Velodrome Roof/Side Glass

Google Animation
Data sets from multiple departments, agencies, etc. shore data in a central repository could be a mix of direct editing in the shared database or ETL process replicating data. Data is stored in an enterprise architected database for multiple applications and users to access.

**Benefits**
- All data being managed in a central location allows for more intelligent analysis
  - One single repository for all spatial data (GIS and CAD formats)
  - Once single repository for document management (other design documents)
- Data is organized for multiple types of users making data extremely relevant to more people within the organization
- Database structured to maintain consistent, non-redundant data

**Disadvantages**
- High upfront stakeholder effort
- If not set up properly:
  - Can be “over” architected
  - Can miss essential data or attributes needed
Las Vegas Valley Water District

Stage 4 - Shared Enterprise Databases

- The District provides water to approximately 325,000 accounts serving over 1,000,000 people
- The AM/FM/GIS Division manages and distributes as-built engineering information to customers
- Pre-existing condition
  - Data editing in ArcGIS with versioned ArcSDE in Oracle Enterprise
  - Using Autodesk Map for CAD data editing and making data “GIS ready”
  - Labor intensive CAD to GIS and GIS to CAD
- Topobase implementation
  - Bring engineering design and geospatial information together into a centralized database environment
    - Both CAD and GIS data stored in Oracle allowing for a single repository for all spatial data accessible by both technology platforms
Database Interoperability

Precision Drafting

AutoCAD Map

Topobase Schema

VALVE

HYDRANT

WATERLINE

Spatial Analysis

ArcMap

SDE Geodatabase

Jobs edits

VALVE

HYDRANT

WATERLINE

Version edits

AutoCAD Map

ORACLE

AutoCAD Map

AutoCAD Map

Intelligent Infrastructure for a Sustainable Future
Clear as mud!
What’s right for you?

*With so many options, what should you do?*

- **Identify your business needs**
  - We’ve talked about the general business problem around CAD and GIS integration
  - What are you specific organizations business problem?
    - need to identify some critical needs not just “nice to haves”
    - Conduct needs assessment
      - could be as simple as conducting interviews or internal workshops
      - hire consultant to identify and document your integration needs
What’s right for you?

With so many options, what should you do?

- **Assess existing technology and business processes**
  - Evaluate existing technology
    - “Technology Bake-off”
  - Evaluate your existing business processes
    - take the opportunity to take a critical look at your business process and make any necessary changes
    - make sure the technology will match your business process
  - Look for new integration opportunities with other enterprise systems
Assess Your Needs

Questions to ask yourself

• Is the exchange a one time event?
• How often is the data changing?
• How is the data being used?
• Who needs to use the data? There may be more people than you realize.
• Who will be the ultimate “owner” of the data?
• What level of detail do you need to pass back and forth between CAD and GIS?
• Is the data related to any other dataset?
• What are the existing GIS/CAD skill sets within your organization?
• What is your existing software and infrastructure?
• What does the end product need to be?
Questions

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