National Consortium for Remote Sensing in Transportation
Streamlining Environmental and Planning Processes

Streamlining Transportation Corridor Planning Processes and Validating the Application of CRS&SI Technologies for Environmental Impact Statements
In a study sponsored by the U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), new and innovative approaches to streamlining environmental and planning processes (SEPP) for transportation corridors was demonstrated by the application of commercial remote sensing data and spatial information technologies.
To provide a basis for making credible Comparisons between the results derived by traditional approaches in the EIS process and the results derived by the application of CRS&SI technologies, we selected a project for which an EIS had been completed. I-69 will provide a vital transportation linkage between Canada and Mexico. Segment of independent utility (SIU) 9 includes I-69 and the new I-269 corridor around Memphis, TN, and into Northwest Mississippi.
Project Overview

• Problem Statement
  – Environmental review process for FHWA
• Transportation Officials
  – Too time consuming- Average of 13 years (FHWA, 2009)
  – Too costly
  – NEPA has “lost its way” (Tripp & Alley, 2003)
  – Integrating Planning and NEPA
  – Make Every Day Count
• Environmentalists (Tripp & Alley, 2003)
  – Process does not place a high value on alternatives
  – Process does not place a high value on public participation
• Purpose of the Study
  – Proof of Concept
  – Traditional EIS with CRS&SI Technologies
Streamlining NEPA

- Public Participation
  - Challenges
- Visualization Technologies
- Multiple Criteria Decision Making (MCDM)
- ECO-PAL
Top Down v Bottom Up

**FEDERAL PERSPECTIVE**

- Wide corridor connecting intermodal hubs and selected places of interest for long term plan

“Emphasizes the National and Regional Economic Development”

**LOCAL PERSPECTIVE**

- Narrow corridors and selected alignments that minimize biophysical, socio-economical and cultural impacts

“Emphasizes: Environmental justice, Environmental Impacts, Cultural and Historical aspects”
Gathering and understanding available geodata is not simple. The process is lengthy, requires communication, early data exchanges, and people skilled at sorting out complex data.

With the SEPP, the geodata useful for transportation corridor planning was catalogued and organized according source, category, and applicability.

As result, the Data Dictionary contains not only a metadata, but all necessary information to rapidly familiarize the users with the data available (date, format, storage, software required, contact person, projects associate with, etc)
Alignment Process Flow

- Public participation
- Stakeholders
- Decision Makers
- Factors/Attributes Ranking
- AHP
- GIS
- Spatial MCDM

Alignment Flow:
1. Alignment 1
2. Alignment 2
3. Alignment 3
Data Dictionary: Cycle

Available Geodata
- CRS&SI
- Environmental knowledge-base
- Transportation needs

Data Gathering / Data Organization
- Data understanding
- Data classification
- Data ranking

Data Storage / Publishing
- Easy and accessible data structure
- Data dictionary

Local Data

State Data

Federal Data
What is MCDM

Systematic way to select the best available alternatives based on different opinions and conflicting priorities and values.

Why should we use it?

- MCDM enables multiple stakeholder preferences to be modeled
- MCDM offers improved coordination and collaboration
- MCDM can be implemented to integrate spatial information
It is a very robust problem solve technique based on pairwise comparisons, developed in early 70’s by Dr. Thomas Saaty as a method to help solve conflicts in economic models.

MCDM has been adapted from AHP to assist numerous corporate and government decision makers in different fields.

Problems are decomposed into a hierarchy of factors and criteria.
Real world needs: **ranking** instead pair-wise inputs
1) Selecting factors
   “positive/negative impact for environment cost, etc.”

2) Ranking criteria (single scenarios)
   “quantifying degree of influence → ex: distance from Wetlands”

3) Ranking factors (combined scenarios)
   “quantifying importance of factors → ex: Wetlands X Agriculture”

4) From ranking to weights
   “mathematical approach based on pair-wise comparisons”

5) Least-Cost Path
   “GIS approach with map algebra ”
Data Dictionary: Cycle

Available Geodata

- CRS & SI
- Environmental knowledge-base
- Transportation needs

Data Gathering / Data Organization

- Data understanding
- Data classification
- Data ranking

Data Storage / Publishing

- Easy and accessible data structure
- Data dictionary

Local Data

State Data

Federal Data
Four factors:
- Drainage density (waterbodies + streams)
- Developed areas
- Wetlands
- Slope

### Criteria
- Avoidance distances
- Avoidance distances
- Avoidance distances
- Avoidance distances

### Factors
- Drainage density
- Developed areas
- Wetlands
- Slope

### Goal
Least-cost path
### Hydrography

#### Distance from Water

<table>
<thead>
<tr>
<th>Distance from Water</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 50 m</td>
<td>3</td>
</tr>
<tr>
<td>50 – 300 m</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 300 m</td>
<td>1</td>
</tr>
</tbody>
</table>

*Source: National Hydrography Dataset*
## Distance from Urbanized Limits

Source: Memphis MPO

<table>
<thead>
<tr>
<th>Distance from MPO</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 2 Km</td>
<td>5</td>
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<tr>
<td>2 – 4 Km</td>
<td>4</td>
</tr>
<tr>
<td>4 – 6 Km</td>
<td>3</td>
</tr>
<tr>
<td>6 – 8 Km</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 8 Km</td>
<td>1</td>
</tr>
</tbody>
</table>
## Wetlands

**Source:** National Land Cover Database 2001

<table>
<thead>
<tr>
<th>Distance from Wetlands</th>
<th>Ranking</th>
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</thead>
<tbody>
<tr>
<td>0 – 50 m</td>
<td>3</td>
</tr>
<tr>
<td>50 – 200 m</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 200 m</td>
<td>1</td>
</tr>
</tbody>
</table>
### Topography

#### Slope vs. Ranking

<table>
<thead>
<tr>
<th>Slope</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5%</td>
<td>1</td>
</tr>
<tr>
<td>5-20%</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 20%</td>
<td>6</td>
</tr>
</tbody>
</table>
Combining Multiple Scenarios

<table>
<thead>
<tr>
<th>Factor</th>
<th>Rank</th>
<th>Weight</th>
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<tbody>
<tr>
<td>UD</td>
<td>7</td>
<td>0.4667</td>
</tr>
<tr>
<td>DD</td>
<td>4</td>
<td>0.2667</td>
</tr>
<tr>
<td>WL</td>
<td>3</td>
<td>0.2000</td>
</tr>
<tr>
<td>SC</td>
<td>1</td>
<td>0.0667</td>
</tr>
</tbody>
</table>

$$0.4667 \times (\text{UD}) + 0.2667 \times (\text{DD}) + 0.2 \times (\text{WL}) + 0.0667 \times (\text{SC})$$

In multiple layer cases, assigned numerical values that provide relative weights are also normalized.

In this approach, each stakeholder may select weights that match their personal and professional perspective and values to create a unique cost surface and cost path!
Results

Path 1
- Urban: 60%
- Wetlands: 20%
- Water: 13%
- Slope: 7%

Path 2
- Urban: 45%
- Wetlands: 22%
- Water: 11%
- Slope: 9%

Path 3
- Urban: 46%
- Wetlands: 27%
- Water: 18%
I-269 Results

• Economic Impact
  – Land Use and REMI

• Freight and Mobility
  – Truck Freight Flow Volumes, Road Classifications and Level of Service

• Environmental Justice
• Archaeology and History
• Environmental and Natural Resources
• REMI did alter the EIA, compared to the traditional EIA
  – Provided a broader scope for the EIA
    • Regions, Multi-Regions, & Statewide
  – Provided a more comprehensive analysis
    • More input/output variables
    • More analysis options
  – Streamlined the EIA
    • 90 minutes for simulations vs. 6-8 months
    • Less data collection
Econ. Impact and Land Use

Planned Alignments

Residential
Commercial
Industrial
Agricultural
Develop Plan
Planned Areas

EIS Planned Alignments
Designed I-269
## Freight and Mobility

<table>
<thead>
<tr>
<th>Location</th>
<th>Proposed I-269</th>
<th>No-Build</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2030 ADT</td>
<td>Level of Service</td>
</tr>
<tr>
<td>MS 304 East of I-55</td>
<td>32,000</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 East of Getwell Rd.</td>
<td>31,000</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 East of Craft Rd.</td>
<td>29,000</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 East of SR 305</td>
<td>26,800</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 East of US 78</td>
<td>32,100</td>
<td>B/C</td>
</tr>
<tr>
<td>MS 304 East of 309</td>
<td>28,400</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 East of 302</td>
<td>28,500</td>
<td>B</td>
</tr>
<tr>
<td>MS 304 North of Stateline</td>
<td>29,200</td>
<td>B</td>
</tr>
<tr>
<td>304-385 Connector North of Holmes</td>
<td>43,000</td>
<td>C/D</td>
</tr>
<tr>
<td>SR 385 North of Nonc. Pkwy</td>
<td>50,900</td>
<td>D</td>
</tr>
<tr>
<td>SR 385 North of Poplar</td>
<td>44,700</td>
<td>D</td>
</tr>
<tr>
<td>SR 385 North of Macon</td>
<td>45,200</td>
<td>C</td>
</tr>
<tr>
<td>SR 385 North of US 64</td>
<td>42,500</td>
<td>D/C</td>
</tr>
<tr>
<td>SR 385 North of Donelson</td>
<td>45,300</td>
<td>D</td>
</tr>
<tr>
<td>SR 385 North of I-40</td>
<td>32,900</td>
<td>C</td>
</tr>
<tr>
<td>SR 385 North of US 70</td>
<td>27,700</td>
<td>B</td>
</tr>
<tr>
<td>SR 385 West of Stewart Rd</td>
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<td>B</td>
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<tr>
<td>SR 385 West of N. Brunswick Rd</td>
<td>38,900</td>
<td>B/C</td>
</tr>
<tr>
<td>SR 385 West of Donnell Rd</td>
<td>38,000</td>
<td>C</td>
</tr>
<tr>
<td>SR 385 West of SR 14</td>
<td>36,500</td>
<td>B</td>
</tr>
<tr>
<td>SR 385 West of Sledge Rd</td>
<td>37,000</td>
<td>C</td>
</tr>
<tr>
<td>SR 385 West of Bethuel Rd.</td>
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<td>B</td>
</tr>
<tr>
<td>SR 385 West of Raleigh-Millington Rd</td>
<td>44,300</td>
<td>C</td>
</tr>
<tr>
<td>I-269 West of US 51</td>
<td>12,200</td>
<td>A</td>
</tr>
</tbody>
</table>
Freight and Mobility Mapped
Environmental Justice
Archeology and History

Possibly Archeology

Historic District

History

Cemeteries

EIS Planned Alignments

Designed I-269
Pulling it Together with GIS
Comparative Scenarios

Combining Inputs

<table>
<thead>
<tr>
<th>RANKING</th>
<th>Factor</th>
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<tbody>
<tr>
<td>8</td>
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<tr>
<td>7</td>
<td>2030 LTP</td>
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<tr>
<td>9</td>
<td>cemetery</td>
</tr>
<tr>
<td>6</td>
<td>economic impact</td>
</tr>
<tr>
<td>6</td>
<td>wetlands</td>
</tr>
<tr>
<td>2</td>
<td>foodplain</td>
</tr>
<tr>
<td>5</td>
<td>forest</td>
</tr>
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</tr>
<tr>
<td>8</td>
<td>section 4 (f)</td>
</tr>
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<td>environmental justice</td>
</tr>
</tbody>
</table>

SCENARIO

Definition of local corridor and least-cost path

Cumulative cost surface computed from local data
**Scenario Comparison**

**Scenario 1: Avoidance**  
Emphasize avoiding developed and environmentally sensitive areas

**Scenario 2: Reuse**  
Emphasize reuse of existing roads
Scenario Comparison

Scenario 1: Avoidance
Emphasize avoiding developed and environmentally sensitive areas

Scenario 2: Reuse
Emphasize reuse of existing roads
Scenario Comparison

Scenario 1: Avoidance
Emphasize avoiding developed and environmentally sensitive areas

Scenario 2: Reuse
Emphasize reuse of existing roads

Automatic Least-Cost Path closely approximates the final planned alignment of I-269!

Automatic Least-Cost Path follows the Existing roads
Scenario Comparison

Scenario 1: Avoidance
Emphasize avoiding developed and environmentally sensitive areas

Scenario 2: Reuse
Emphasize reuse of existing roads
ECO-PAL: Environmental Corridor Optimization – Planning Alignment Toolkit

• The GIS implementation of the project’s multi-criteria decision making (MCDM) was given the name “ECO-PAL” at a May, 2009 workshop.

• ECO-PAL collects stakeholder values for environmental factors and automatically generates potential alignments that “self-screen” for the environmental factors included.

• Resultant ECO-PAL alignments may be explored, compared, evaluated, and modified to meet project needs.
 alternatives considered for EIS ground work as presented in the I-269 Final EIS.

ECO-PAL output corridors considered for EIS ground work.

I-269 Final Alignment.
Benefits of ECO-PAL

Not an engineering least-cost path, ECO-PAL enables planning and environmental linkages (PEL) via data-driven alignment generation. ECO-PAL provides capabilities to:

- Capture differing environmental values to generate alignments,
- Modify approaches or create compromise scenarios that contain aspects of multiple stakeholder opinions,
- Enable participants to visualize alignments generated in the context of environmental factors,
- Create apt comparisons among opinions and alignments, and
- Incorporate further adjustments and refinements as desired.
CRS&SI Technologies Provide Rich Capabilities to Enhance EIS Process

Geospatial information technologies provide a rich and expanding set of platforms for data analysis, visualization, and comparison or results.

ECO-PAL may be used alongside traditional EIS to deliver understanding of the costs and benefits as well as performance merits of new approaches to project development.
Final Corridor Design and ECO-PAL Corridor: Stay on The ECO-PAL ‘Green’ Alignment Pathway

The ECO-PAL Toolkit provided a framework for employing:

- remote sensing data
- geodata layers
- collaborative input
- environmental factors
- human values
- spatial technologies, and
- decision support.

Results show that the project objectives were accomplished determining that CRS&SI can automate EIS practices to streamline the delivery of alignments that closely match those generated in an actual EIS.
• This demonstration shows that AHP-Based MCDM as implemented in ECO-PAL may be effectively used to arrive at generalized corridors using highly available data, and to deliver refined alignments with enhanced data and ECO-PAL scenario refinement.

• The scenarios generated show that ECO-PAL is capable of delivering results that almost exactly correspond to human practices used to arrive at a final alternative selection per the I-69/269 FEIS.
Next Steps: Reduce Methods to Practice Through Deployment Case Study Projects

Prior to implementing results and technologies presented, there remain research needs and next steps such as the following:

- Required collaborative decision-making uses and targeted streamlining benefits of ECO-PAL should be defined.
- ECO-PAL software, data, and methods must be refined and systematized to quantify performance and streamlining benefits.
- Hurdles remain to be overcome in data, project management, resources agency acceptance, and DOT agency support.

The project team recommends that deployment case studies, conducted in collaboration between practitioners and the research team, are needed to quantify benefits, identify best practices, and effectively reduce research results to practical application.
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