Case Studies in Implementation of Cross-Asset Resource Allocation Tools

Bill Robert, Spy Pond Partners
Craig Secrest, High Street Consulting
2018 TRB Transportation Asset Management Conference
spy pond partners, llc
Presentation Overview

• Background and Context
  • MODA Overview
  • NCHRP Research

• NCHRP Project 08-103 Case Studies
  • Arizona DOT
  • Delaware Valley Regional Planning Commission (DVRPC)
  • California DOT (Caltrans)
  • Maryland DOT and Maryland State Highway Administration (SHA)

• Lessons Learned
Cross-Asset Resource Allocation Overview

Background and Context

- Factors to consider when deciding how to invest across assets and investment areas (e.g., safety, mobility, asset preservation)
  - What’s the right investment strategy for a given asset?
  - How do I incorporate broader agency goals and objectives in project-level decisions?
  - How do I prioritize investments across assets and investment areas given funding limitations?
- Typical strategy is to divide asset/investment types into group and allocate within asset/investment type
- More recently agencies have begun to revisit cross-asset resource allocation approaches
Background and Context

Application of MODA to Cross-Asset Investments

- Multi-Objective Decision Analysis (MODA) provides an approach for prioritizing cross-asset/multi-objective decisions
- Basic approach
  - Define a utility or value function incorporating an agency’s objectives
  - Calculate the utility/value for individual candidate projects (or groups of projects)
  - Prioritize considering the utility of each candidate and its cost
- Also referred to using Multi-Criteria Decision-Making (MCDM) or other acronyms
- Potential benefits
  - More efficient and effective use of funding
  - Improved system performance
  - Improved transparency and repeatability
Challenges in Applying MODA

- **Defining the scope of the analysis**
  - Often end up prioritizing projects within a selected set of investment categories for a single decision period

- **Developing a set of candidates**
  - Where do these come from?

- **Defining the utility function**
  - Can be hard to quantify goals and objectives – and then obtain needed data

- **Weighting objectives**
  - Often the Analytical Hierarchy Process (AHP) is used to establish weights through a set of pairwise comparisons
  - Other approaches, such Data Envelopment Analysis (DEA) circumvent need for this additional step
Background and Context

NCHRP Research in Cross-Asset Resource Allocation for Transportation Asset Management

- **NCHRP Project 08-91 (2015)**
  - Initial effort to research cross-asset resource approaches for transportation asset management
  - Project team: CH2M Hill, High Street Consulting and Burns & McDonnell
- **NCHRP Project 08-103 (scheduled for completion in 2018)**
  - Objective is to implement the framework and prototype tool from NCHRP Report 806 through a set of case studies
  - Will also result in revised spreadsheet and web tools building on the previous research
  - Performed an initial “beta test” with Utah DOT followed by a set of four case studies
  - Project team: Spy Pond Partners, High Street Consulting and Burns & McDonnell
Arizona DOT Case Study

- Used MODA for the long range plan updates
  - What Moves You Arizona (WMYA) 2035/2040
  - High-level approach for determining how to allocate between different investment areas
- Established “Alternative Investment Choices” (AICs) and “Recommended Investment Choices” (RIC) to identify desired allocation of resources between highway preservation, modernization, and expansion
  - WMYA 2035 RIC based largely on qualitative assessments of expected system performance
  - WMYA 2040 RIC more data-driven approach and performance-informed
Framework for AIC/RIC Development

WMYA System Goals
- Mobility, Reliability & Accessibility
- Safety
- Preservation

Investment Types
- System Expansion
- Technology Deployment
- Accessibility
- Preservation
- Safety

Performance Metrics
- Auto/Truck Delay
- User Costs
- % ITS Needs Met
- % Interchange Needs Met
- % Bridges Good
- % Pavement Good
- % Safety Needs Met

Major Investment Categories
- Expansion
- Modernization
- Preservation
Arizona DOT

Scenario Analysis

- Established performance curves to define anticipated performance outcomes
- Performed pairwise comparison to determine priority weight on goals
  - Utilized Decision Lens software
- Presented scenario analysis results at workshop attended by stakeholders
Delaware Valley Regional Planning Commission (DVRPC) Case Study

- **DVRPC Role**
  - Establishing the region’s long-range metropolitan transportation plan
  - Leading bi-annual development of Transportation Improvement Programs (TIPs)
  - Utilizing a MODA approach for project evaluation and selection in the TIPs
Establishing Project Evaluation Criteria: Principles

- Alignment with planning goals and objectives
- Differentiating to produce a clear ranking
- Representative of all member counties
- As quantitative as possible
- Measurable using regularly available data
- Relevant for a diverse set of projects
- Comprehensive to cover regional goals
- Simple with concise, non-redundant measures
- Understandable for any audience
Project Scoring and Selection

- Used pairwise comparison to select priority weights on evaluation criteria
- Calculate score/cost for each candidate project
- Regional Technical Committee recommends final project selection considering:
  - Score/Cost value
  - Geographic equity
  - Contribution to fostering a multi-modal system
  - Level of political support
- Process and projects (but not numerical scores) are made available for public comment
Maryland DOT Case Study

- Implementing state legislation for prioritizing major expansion projects over $5 million for inclusion in the Consolidated Transportation Plan (CTP)
- Evaluating projects across 9 goals and 23 measures established in the legislation
- Conducted series of workshops to determine evaluation criteria for each measure based on available data and resources
  - Wherever possible utilized quantitative methods
  - Qualitative evaluation criteria used in some cases
- Implemented the resulting scoring approach in Citygate’s iOpenDecision
Maryland DOT

Goals and Weights

- Utilized Delphi method to establish the weights on each of the goals
  - Stakeholders vote on the weights for each goal
  - Discuss difference of opinion
  - Ultimately reach consensus
Maryland DOT State Highway Administration Case Study

- For the NCHRP pilot tested an adapted version of the methodology used for MDOT to prioritize highway asset management projects
- Adapted methodology includes 4 goals and 7 measures
  - Safety (1 measure)
  - System Preservation (1 measure)
  - Mobility (2 measures)
  - Environment and Community (3 measures)
- Tested prioritizing by score/cost and using DEA
- SHA is evaluating pilot results and feasibility of future implementation of a MODA approach for helping prioritize
Cross-Asset Resource Allocation Tool: Data Entry

- After evaluating set of sample projects, data and scores were used in the cross-asset resource allocation tool

<table>
<thead>
<tr>
<th>Performance Measures for Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Level Performance Measure</td>
</tr>
<tr>
<td>Goal A Measure 1</td>
</tr>
<tr>
<td>Goal B Measure 1</td>
</tr>
<tr>
<td>Goal C Measure 1</td>
</tr>
<tr>
<td>Goal C Measure 2</td>
</tr>
<tr>
<td>Goal D Measure 1</td>
</tr>
<tr>
<td>Goal D Measure 2</td>
</tr>
<tr>
<td>Goal D Measure 3</td>
</tr>
</tbody>
</table>

Input performance measures and weights
### Cross-Asset Resource Allocation Tool: Sample Ranking

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Investment Area</th>
<th>Cost</th>
<th>Overall Score</th>
<th>Overall Score/Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 10</td>
<td>System Preservation</td>
<td>4635</td>
<td>0.706</td>
<td>1.000</td>
</tr>
<tr>
<td>Project 9</td>
<td>System Preservation</td>
<td>6180</td>
<td>0.706</td>
<td>0.750</td>
</tr>
<tr>
<td>Project 7</td>
<td>System Preservation</td>
<td>5068.8</td>
<td>0.461</td>
<td>0.596</td>
</tr>
<tr>
<td>Project 1</td>
<td>Bridge Replacement</td>
<td>8607</td>
<td>0.590</td>
<td>0.450</td>
</tr>
<tr>
<td>Project 6</td>
<td>Widen Roadway</td>
<td>24889</td>
<td>0.554</td>
<td>0.146</td>
</tr>
<tr>
<td>Project 4</td>
<td>Widen Roadway</td>
<td>18109</td>
<td>0.218</td>
<td>0.079</td>
</tr>
<tr>
<td>Project 2</td>
<td>Bridge Replacement</td>
<td>51333</td>
<td>0.574</td>
<td>0.073</td>
</tr>
<tr>
<td>Project 8</td>
<td>System Preservation</td>
<td>21294</td>
<td>0.227</td>
<td>0.070</td>
</tr>
<tr>
<td>Project 5</td>
<td>Widen Roadway</td>
<td>121211</td>
<td>0.864</td>
<td>0.047</td>
</tr>
<tr>
<td>Project 11</td>
<td>TSM&amp;O</td>
<td>151000</td>
<td>1.000</td>
<td>0.043</td>
</tr>
<tr>
<td>Project 3</td>
<td>Mobility and Safety</td>
<td>105407</td>
<td>0.304</td>
<td>0.019</td>
</tr>
</tbody>
</table>
Cross-Asset Resource Allocation Tool: Sample Budget Allocation

<table>
<thead>
<tr>
<th>Investment Area</th>
<th>Minimum Allocation</th>
<th>Maximum Allocation</th>
<th>Current Allocation</th>
<th>Current % Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSM&amp;O</td>
<td>0</td>
<td>$151,000</td>
<td>$0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Widen Roadway</td>
<td>0</td>
<td>$164,209</td>
<td>$164,209</td>
<td>52.06%</td>
</tr>
<tr>
<td>System Preservation</td>
<td>0</td>
<td>$37,178</td>
<td>$37,178</td>
<td>11.79%</td>
</tr>
<tr>
<td>Bridge Replacement</td>
<td>0</td>
<td>$59,940</td>
<td>$8,607</td>
<td>2.73%</td>
</tr>
<tr>
<td>Mobility and Safety</td>
<td>0</td>
<td>$105,407</td>
<td>$105,407</td>
<td>33.42%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Name</th>
<th>TSM&amp;O</th>
<th>Cost</th>
<th>Funding Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 11</td>
<td>TSM&amp;O</td>
<td>$151,000</td>
<td>No Build</td>
</tr>
<tr>
<td>Project 5</td>
<td>Widen Roadway</td>
<td>$121,211</td>
<td>Build</td>
</tr>
<tr>
<td>Project 10</td>
<td>System Preservation</td>
<td>$4,635</td>
<td>Build</td>
</tr>
<tr>
<td>Project 9</td>
<td>System Preservation</td>
<td>$6,180</td>
<td>Build</td>
</tr>
<tr>
<td>Project 1</td>
<td>Bridge Replacement</td>
<td>$8,607</td>
<td>Build</td>
</tr>
<tr>
<td>Project 2</td>
<td>Bridge Replacement</td>
<td>$51,333</td>
<td>No Build</td>
</tr>
<tr>
<td>Project 6</td>
<td>Widen Roadway</td>
<td>$24,889</td>
<td>Build</td>
</tr>
<tr>
<td>Project 7</td>
<td>System Preservation</td>
<td>$5,069</td>
<td>Build</td>
</tr>
<tr>
<td>Project 3</td>
<td>Mobility and Safety</td>
<td>$105,407</td>
<td>Build</td>
</tr>
<tr>
<td>Project 8</td>
<td>System Preservation</td>
<td>$21,294</td>
<td>Build</td>
</tr>
<tr>
<td>Project 4</td>
<td>Widen Roadway</td>
<td>$18,109</td>
<td>Build</td>
</tr>
</tbody>
</table>
Case Studies

Caltrans

- Utilizing MODA to prioritize projects in the California State Highway Operation and Protection Program (SHOPP)
- Evaluating projects across 5 goals and 12 measures
- Exploring Data Envelopment Analysis (DEA) as an option for prioritizing goal scores
  - Results highly correlated with score/cost ratio ranking
- Next presentation further details this case
Lessons Learned

- Importance of structuring the problem
  - Scoring criteria should be easy to understand
  - Avoid creating overlapping or ambiguous measures
  - Establishing criteria for good/fair/poor conditions or high/low scores as applicable

- Data issues
  - Often hard to get quality data needed to support the process
  - Where data are not available tendency is to fall back on subjective scoring approaches

- Many different options for implementing MODA
  - Variations of goals/objectives and measures
  - Approaches for weighting objectives: AHP vs. Delphi vs. DEA
  - Systems to support the process, including COTS system and NCHRP tools
Thank You!

Contact information
For more info, please contact us at wrobert@spypondpartners.com