Tools and Processes to Enhance TAM: Resource Allocation

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Presentation Overview

- Background and Context
  - Relationship to asset management
  - Approaches to cross asset resource allocation
  - NCHRP research efforts
- NCHRP Project 08-103 Resource Allocation Guidance
- Supporting Analytical Tools
- Future Directions
Resource Allocation for Transportation Asset Management: Key Points

• Enabling effective resource allocation is fundamental to transportation asset management
• Potential benefits of a structured allocation approach
  • Better alignment with agency goals and objectives
  • More efficient use of scarce resources
  • Repeatability
  • Transparency
• Asset management resource allocation is inherently a complicated, cross-asset, multi-objective problem
• Structured approaches to resource allocation can help improve the process but ultimately people make the decisions
Factors to consider

- 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?

Basic strategies

- Divide asset/investment types into group and allocate within asset/investment type supported by management systems (top down)
- Define candidate investments across asset/investment area and prioritize candidates together (bottom up)
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 using a “bottom-up” approach
- Basic steps
  - 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
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
Background and Context

NCHRP Report 806 Framework

How can we link planning and programming processes to ensure the optimal allocation of limited resources across asset classes?

- How can we better serve our stakeholders in the future?
- How can we best predict and monitor progress towards goals?
- How can we assess investment impacts prior to implementation?
- How can we compare and rank dissimilar projects across investment areas?
- How can we maximize impact given fiscal constraints and agency/stakeholder priorities?

Goals and Objective Identification
Performance Metric Evaluation
Project Impact Assessment
Decision Science Application
Trade-off Analysis
Many agencies have made progress in cross-asset resource allocation since completion of NCHRP Report 806

- Need is not so much to obtain assistance with the Report 806 tool as to provide supplemental guidance and tools to help facilitate future progress

- Biggest issues in implementing cross-asset approaches relate to structuring the problem and obtaining needed data
  - Most approaches are data hungry
  - Various systems are available for supporting a cross-asset approach given data, including the prototype tool provided with NCHRP Report 806

- Still a significant gap between testing concepts and institutionalizing improved business processes
Background and Context

NCHRP 08-103: Case Studies

- Delaware Valley Regional Planning Commission (DVRPC)
  - Calculates a score considering 9 criteria for candidate projects
  - Used to prioritize projects for inclusion in the TIP

- Arizona DOT (ADOT)
  - Used cross-asset resource allocation concepts to inform development of the long-range plan
  - For the 2040 plan update – created different investment scenarios in management systems and obtained feedback from decision makers and the public on right mix between preservation, modernization and expansion
Background and Context

NCHRP 08-103: Case Studies (cont.)

- California DOT (Caltrans)
  - Developing an approach for scoring candidate projects for inclusion in its asset preservation program (SHOPP)
  - Approach considers 5 agency goals and 12 measures
  - Measures structured to yield values analogous to economic benefits

- Maryland DOT (MDOT) and State Highway Administration (SHA)
  - Spurred by legislation MDOT implemented a MODA approach for prioritizing expansion projects considering 9 goals and 23 measures
  - Simplified approach was tested for SHA for application to asset management projects using 4 goals and 7 measures
Common Conventions in Recent Cross-Asset/MODA Implementation Efforts

- Single period decision
- Analytical Hierarchy Process (AHP) or Delphi approach used to establish weights on objectives
- Utility combined for different objectives to obtain a single value for each project
- Complicating factors omitted from the initial prioritization and handled externally
  - Multiple funding sources
  - Timing of expenditures
  - Geographic equity
- Subjective scoring often used in lieu of quantitative data
Common Challenges

- 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
- Weighting objectives
  - See guidance for discussion of how to circumvent
- Obtaining the needed data!
NCHRP 08-103 Guidance for Implementing Cross Asset Resource Allocation

- Step 1: Establish the scope
- Step 2: Define goals and objectives
- Step 3: Select performance measures and evaluation criteria
- Step 4: Assess data and analytical capabilities
- Step 5: Prototype the approach
- Step 6: Set weights on goals and objectives
- Step 7: Apply the model
- Step 8: Communicate the results
Step 1: Establish the Scope

- What assets?
- What types of investments?
- What’s the decision period?
- How does the approach fit into the existing business process?
- How will the results be used?
Step 2: Define Goals and Objectives

- Should consistent with other agency documents
- May consider a subset of broader agency goals and objectives depending on analysis scope
- See common goals at right
- Ideally should not have more than 5 to 7 goals
- Goals should not overlap!

Typical Investment Objectives
- Mobility
- Preservation
- Safety
- Security
- Resilience
- Environment
- Community
- Economic Development
- Accessibility
- Social Justice
Step 3: Select Performance Measures and Evaluation Criteria

- Performance measures quantify progress towards goals and objectives
- There should be one or more measure for each objective
- Ideally measures should be quantitative rather than qualitative
  - Quantitative: average annual reduction in fuel consumption in gallons
  - Qualitative: 1-5 score evaluating degree to which project promotes reduction in emissions
- Need to consider how measures scale based on project size
- Ultimately will need to normalize the measure to obtain a utility
  - One approach is to convert all measures into 0-100 scores
  - An alternative is to construct measures analogous to economic benefits ($)
Step 4: Assess Data and Analytical Capabilities

- Do we have the data needed to support the analysis scope and recommended set of measures?
- What data can be obtained from existing systems?
- Approaches for addressing data challenges
  - Use predictive models to obtain values for individual projects or defaults by project type
    - Example – annual benefit of mitigating an acre of wetland
  - Revisit analysis scope and measures
  - Collect more data
- Steps 3 and 4 are iterative
Guidance

Step 5: Prototype the Approach

- Document the approach and assumptions
- Collect data for a set of sample projects
  - Sample set should cover range of project types and measures included in the analysis
  - Typically need 15 or more projects to test the approach
- Calculate the utility for each project
  - Apply the normalizing approach developed in Step 3
  - Assume some nominal weighting of objectives as required
- Review the utility for each project and utility/cost
- As needed revise the approach
Step 6: Set Weights on Goals and Objectives

- **Common approaches**
  - Pairwise comparison (used in AHP)
  - Delphi method
- **Approaches that sidestep the need to set explicit weights in this step**
  - Data Envelopment Analysis (DEA): this approach tries to maximize progress towards each objective without determining the value of achieving one objective versus another
  - Use of measures analogous to economic benefits

*Use pairwise comparison when you have:*
- A small number of objectives
- A sense of the scale
- An authoritative set of decision makers
Step 7: Apply the Model

- Establish process for
  - Identifying candidate investments
  - Calculating measures for each candidate
  - Prioritizing candidates
  - Using initial prioritizing to support resource allocation
  - Updating key assumptions and parameters

- Implement a system to support the process
  - Depending on problem size may be able to support the process in a spreadsheet, at least initially
  - NCHRP tools provide means for initial implementation
  - Various COTS systems available, including DecisionLens and Citygate iOpenDecision
Step 8: Communicate the Results

- Need to document key assumptions, including the approach used to calculate weights on objectives or other parameters that impact prioritization
- Ideally should make prioritization results available to enhance transparency
- Important to clarify why funding decisions may differ from initial priorities yielded by the process
Analysis Tools

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Initially developed and documented in NCHRP Report 806
- Revised in the current work and tested at case study agencies
- Walks users through the process of
  - Setting weights on goals through pairwise comparison
  - Scaling project scores
  - Optimizing the portfolio of selected projects based on the budget
Analysis Tools

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Performance Measures and Project Impacts

<table>
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<tr>
<th>Project Name</th>
<th>Investment Area</th>
<th>Cost</th>
<th>Safety No Build</th>
<th>Build</th>
<th>Air Quality and Health No Build</th>
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Analysis Tools

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Weights and Overall Scores

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<th>Performance Measure</th>
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<td>Air Quality and Health</td>
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## Cross-Asset Resource Allocation Tool (Spreadsheet)

### Optimization

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Analysis Tools

Cross-Asset Resource Allocation Tool (Web Tool)

- **Motivation**
  - Recommendation to test use of DEA raised in the Caltrans case study

- **Web tool**
  - Import or enter projects, including a description, cost and value by objective
  - Run the DEA web service to prioritize projects and determine which to fund given a specified overall budget
  - Visualize the results

- **Web service**
  - Take project data and an overall budget as inputs
  - Computes the relative efficiency of each project using DEA
  - Reports back relative efficiency and which projects to fund given the budget
Analysis Tools

Cross-Asset Resource Allocation Tool (Web Tool)
Future Directions for Asset Management Resource Allocation

- Continued implementation of improved cross-asset resource allocation approaches using MODA
- More agencies likely to experience success as experience is gained
  - Better integrating data and measures from management systems with the prioritization approach
  - Defining measures that are objective and quantifiable – and for which data are available
  - Better incorporating assumptions and lessons learned from benefit/cost analysis in the methodology
  - Further third party review of approaches and outcomes
- DEA and/or other techniques may help address inherent issues observed in initial efforts to implement MODA
Thank You!

Contact information
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