Tools and Processes to Enhance TAM: Resource Allocation

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2018 TRB Transportation Asset Management Conference

July 15, 2018

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Presentation Overview

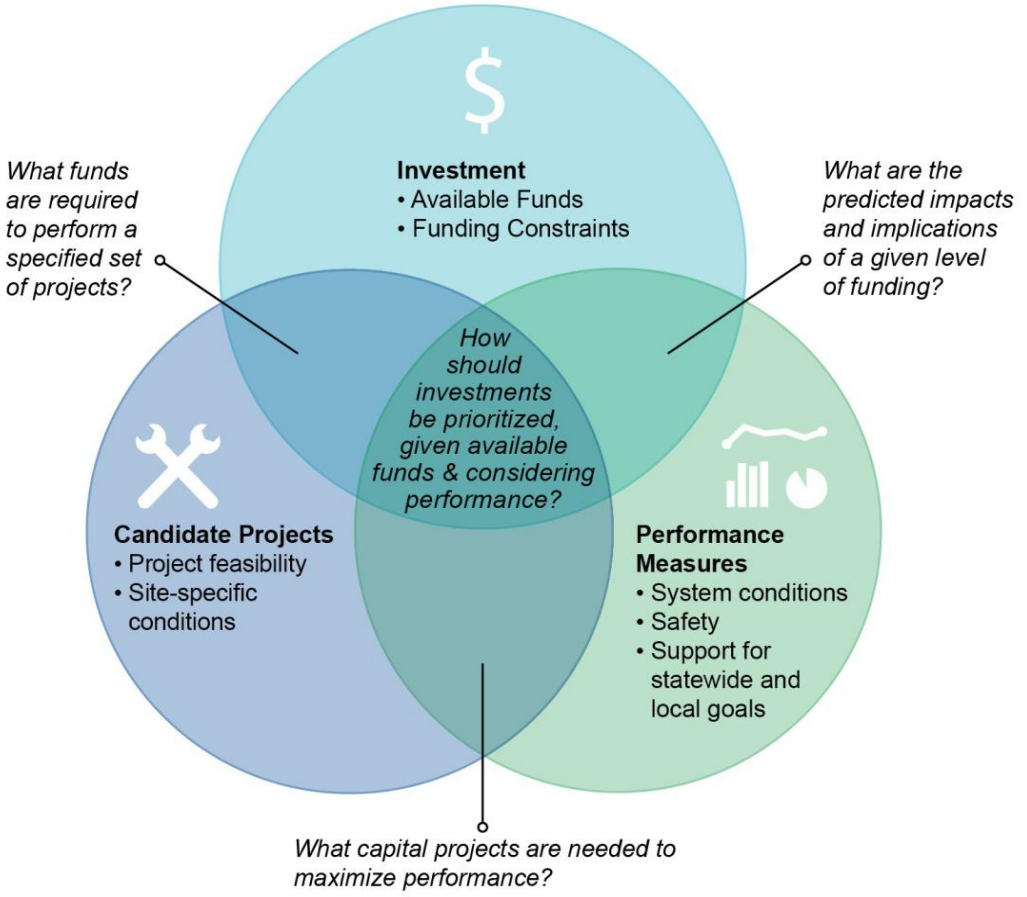
- Background and Context
  - Relationship to asset management
  - Approaches to cross asset resource allocation
  - NCHRP research efforts
- NCHRP Project 08-103 Resource Allocation Guidance
- Supporting Analytical Tools
- Future Directions

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

Cross-Asset Resource Allocation Overview

- 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)



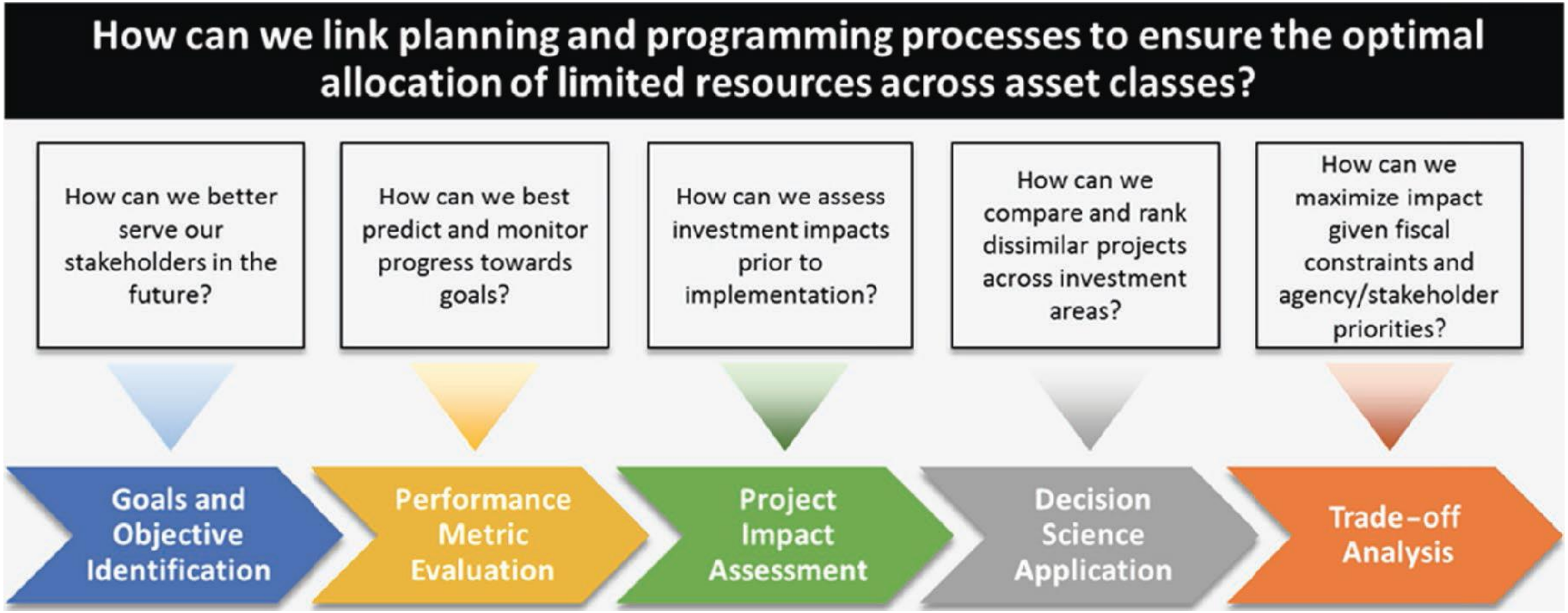
Application of MODA to Cross-Asset Investments

- 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

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
  - Resulted in NCHRP Report 806: Guide to Cross-Asset Resource Allocation and the Impact on Transportation System Performance – and a prototype tool
  - 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

NCHRP Report 806 Framework



NCHRP 08-103: Lessons from Initial “Beta Test”

- 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

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

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

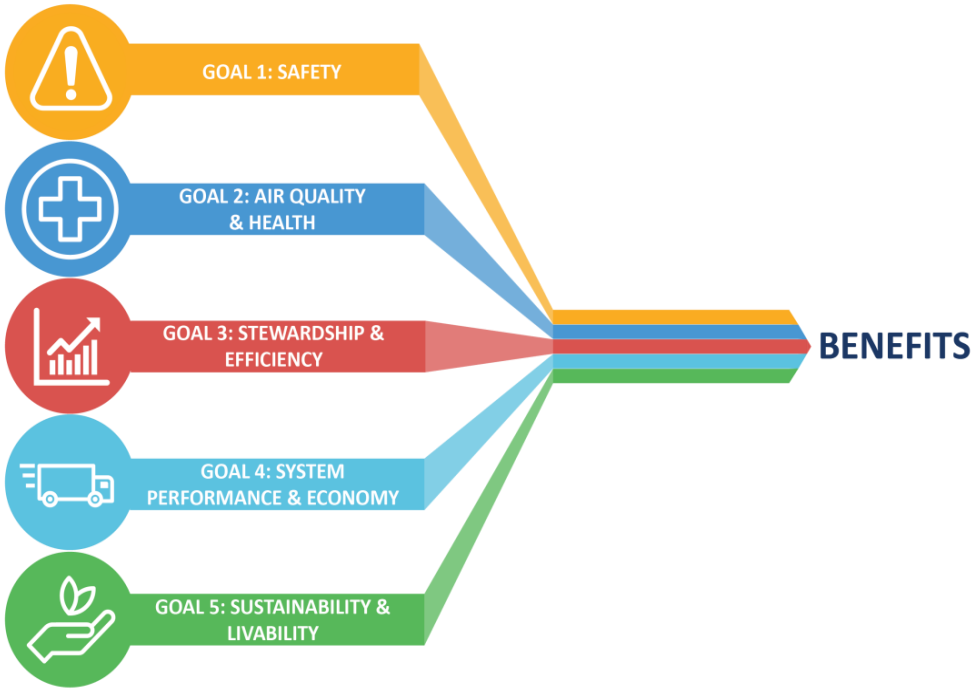
- Defining the scope of the analysis
  - Often end up prioritizing projects within a selected set of investment categories for a single decision period
- Developing a set of candidates
  - Where do these come from?
- Defining the utility function
  - Can be hard to quantify goals and objectives
- Weighting 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

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

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

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Performance Measures and Project Impacts

Performance Measures for Analysis

Project-Level Performance Measure	*Program Objective*
Safety	Maximize Total Safety
Air Quality and Health	Maximize Total Air Quality and Health
Stewardship and Efficiency	Maximize Total Stewardship and Efficiency
System Performance and Economy	Maximize Total System Performance and Economy
Sustainability and Livability	Maximize Total Sustainability and Livability

			Safety		Air Quality and Health		Stewardship and Efficiency	
Project Name	Investment Area	Cost	No Build	Build	No Build	Build	No Build	Build
18593	Rural	504.54	0	827710.65	0	4183127.1	0	5322240
17370	Urban	75.314	0	19237289	0	474679.78	0	0
16167	Urban	38.547	0	821528.04	0	4307095.7	0	0
13324	Rural	40.261	0	12333.789	0	2758593.1	0	0
20299	Urban	14.383	0	944222.09	0	3736308.8	0	0
16832	Rural	5.95	0	337.70842	0	3902.5287	0	13219686
11368	Rural	102.604	0	6431.0331	0	1678558.7	0	0
16560	Urban	8.472	0	604361.83	0	1779688.2	0	0

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Weights and Overall Scores

Performance Measure	Weight
Safety	100.00%
Air Quality and Health	100.00%
Stewardship and Efficiency	100.00%
System Performance and Economy	100.00%
Sustainability and Livability	100.00%

Project Name	Investment Area	Cost	Overall Score	Overall Score/Cost
16832	Rural	5.95	**0.337**	1.000
20299	Urban	14.383	**0.467**	0.573
16560	Urban	8.472	**0.236**	0.491
13838	Urban	2.59	**0.053**	0.361
16014	Urban	11.701	**0.175**	0.263
16167	Urban	38.547	**0.538**	0.246
15897	Rural	16.602	**0.213**	0.227
17782	Urban	13.701	**0.174**	0.224
18237	Urban	3.21	**0.041**	0.223
13324	Rural	40.261	**0.475**	0.208
16085	Urban	6.723	**0.075**	0.197

Cross-Asset Resource Allocation Tool (Spreadsheet)

- Optimization

Overall Budget	Current Allocation	Program Score
2127	2034.04	97.40%

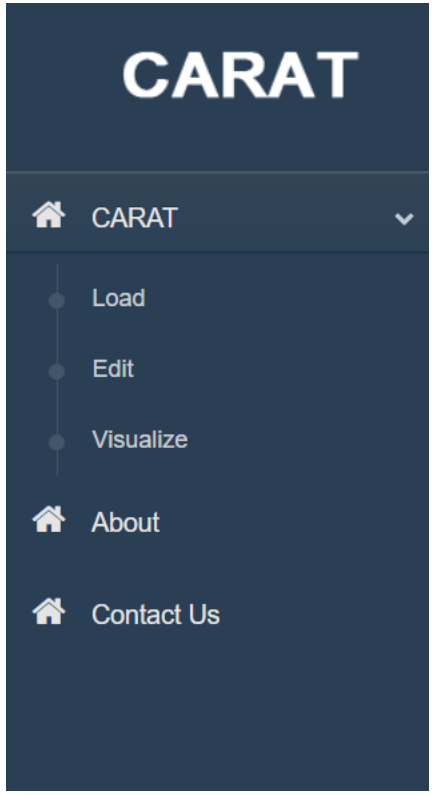
Investment Area	Minimum Allocation	Maximum Allocation	Current Allocation	Current % Allocation
Rural	0	1581.13	980.707	48.21%
Urban	0	1425.02	902.019	44.35%
Suburban	0	184.006	151.314	7.44%

Project Name	Investment Area	Cost	Funding Status	Must Fund	Overall Score
18593	Rural	504.54	Build		1.000
17370	Urban	75.314	Build		0.575
16167	Urban	38.547	Build		0.538
13324	Rural	40.261	Build		0.475
20299	Urban	14.383	Build		0.467
16832	Rural	5.95	Build		0.337
11368	Rural	102.604	Build		0.332
16560	Urban	8.472	Build		0.236
15897	Rural	16.602	Build		0.213
17031	Urban	42.277	Build		0.206

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

Cross-Asset Resource Allocation Tool (Web Tool)



Account Summary

My Account

You are logged in as: carat

Files last uploaded at: 07/12/2018 07:21:40 pm

Reset Password

Load CSV Data File

Edit Projects

Visualize Results

Edit

Carat

Project ID	Description	Cost	Congestion	Safety	Accessibility	Environmental Quality	Economic Development	new	Land Use	Relative Efficiency	Sele
80	b	3144181	0.914752305	0.029976663	0.036988524	0.220727994	0.433153369	0.433153369	2.854612891	0.00	0
87	b	650000	0	2.36767275	0	0.007141205	0.508906813	0.508906813	0	0.78	1
41	b	1240076	0.003513981	0.101381652	0.017730763	0.004828635	0.018746853	0.018746853	1.374081352	0.19	1
133	b	90915519	0.912557069	0	0	0.007928889	1.389740575	1.389740575	0	0.03	0
16	b	822140	0	0.153899077	0	0.004803127	3.356799257	3.356799257	1.045048143	0.17	1
42	b	150454	0.0000112	0	0	1.440290442	0.068754689	0.068754689	0	0.21	1
70	b	2744657	0.0000225	16.74568966	0	0.003963155	0.109193879	0.109193879	0	0.01	0
40	b	43096727	14.77212465	0.326456632	0.098191615	0.015039524	0.420395028	0.420395028	0.770824327	0.10	1
141	b	51326837	0.062308941	0.026939655	0.13719739	0.183050887	2.826951885	2.826951885	0	0.02	0
103	b	603594.32	0.081822979	0.746137633	0.107215125	0.00589306	0.130204319	0.130204319	0.500393005	0.01	0
139	b	1078947	0.022983882	1.910000396	0	0.00286586	2.251736719	2.251736719	0	0.50	1
132	b	52980000	14.47000003	0.071127749	0.057716028	0.443899883	0.600973005	0.600973005	1.615160149	0.13	1

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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