### TECHNICAL REPORT DOCUMENTATION PAGE

| | | |
|---|---|---|
| **1. Report No.**<br>SPR-1764 | **2. Government Accession No.**<br>N/A | **3. Recipient's Catalog No.** |
| **4. Title and Subtitle**<br>Multi-Objective Decision Analysis and Optimization Model for Transportation Investment Decision-Making at MDOT | | **5. Report Date**<br>1/29/2026<br>**6. Performing Organization Code**<br>N/A |
| **7. Author(s)**<br>William Robert<br>Abigail Bliss<br>Constance Morrison | | **8. Performing Organization Report No.**<br>N/A |
| **9. Performing Organization Name and Address**<br>Spy Pond Partners, LLC<br>37 Broadway<br>Arlington, Massachusetts 02474 | | **10. Work Unit No.**<br>N/A<br>**11. Contract or Grant No.**<br>Contract #2024-0192 |
| **12. Sponsoring Agency Name and Address**<br>Michigan Department of Transportation (MDOT)<br>Research Administration<br>8885 Ricks Road<br>P.O. Box 33049<br>Lansing, Michigan 48909 | | **13. Type of Report and Period Covered**<br>Final Report, 1/30/2024 - 1/30/2026<br>**14. Sponsoring Agency Code**<br>N/A |

**15. Supplementary Notes**

Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MDOT research reports are available at www.michigan.gov/mdotresearch.


**16. Abstract**

Multi-objective decision analysis (MODA) provides transportation agencies with a structured process for identifying a set of investments that delivers the greatest impact toward their objectives. In the presented research, the research team developed a prototype MODA-based approach for prioritizing pavement rehabilitation and reconstruction projects at the Michigan Department of Transportation (MDOT). Research activities included a review of best practices and MODA applications, development of goals and measures for quantifying projects' anticipated impacts, and implementation and evaluation of the proposed MODA approach using 39 test projects. The research demonstrated that a MODA-based approach can be used to assess and prioritize the target set of projects based on their anticipated asset condition, safety, accessibility and mobility, and environmental impacts. Further research could include implementation and evaluation of the proposed approach with additional data or decision-support tools, as well as adaptation of the MODA approach to other program areas at MDOT.


| | |
|---|---|
| **17. Key Words**<br>Resource allocation, project prioritization, multi-objective decision analysis, transportation asset management | **18. Distribution Statement**<br>No restrictions. This document is also available to the public through the Michigan Department of Transportation. |

| | | | |
|---|---|---|---|
| **19. Security Classif. (of this report)**<br>Unclassified | **20. Security Classif. (of this page)**<br>Unclassified | **21. No. of Pages**<br>85 | **22. Price**<br>N/A |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

**Acknowledgements**

The research team would like to thank the Michigan Department of Transportation (MDOT) for sponsoring this research effort. We appreciate, in particular, the support of Michael Case, Project Manager (PM), and the MDOT Research Advisory Panel (RAP).

**Research Report Disclaimer**

"This publication is disseminated in the interest of information exchange. The Michigan Department of Transportation (hereinafter referred to as MDOT) expressly disclaims any liability, of any kind, or for any reason, that might otherwise arise out of any use of this publication or the information or data provided in the publication. MDOT further disclaims any responsibility for typographical errors or accuracy of the information provided or contained within this information. MDOT makes no warranties or representations whatsoever regarding the quality, content, completeness, suitability, adequacy, sequence, accuracy or timeliness of the information and data provided, or that the contents represent standards, specifications, or regulations

This material is based upon work supported by the Federal Highway Administration under SPR-1764. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Federal Highway Administration."

If you require assistance accessing this information or require it in an alternative format, contact the MDOT Americans with Disabilities Act (ADA) coordinator at www.Michigan.gov/MDOT-ADA.

# Table of Contents

# List of Tables

## List of Figures

# Executive Summary

Transportation Asset Management (TAM) supports transportation agencies in tracking their physical assets and identifying asset investment approaches that align with agency objectives. Increasingly, agencies are turning toward data-driven, performance-based strategies to drive resource allocation processes and improve their approach to TAM. Multi-objective decision analysis (MODA) can provide a structured approach to this type of decision-making that incorporates a range of factors into transportation project selection.

The Michigan Department of Transportation (MDOT) sponsored research into the use of MODA in its Road Rehabilitation and Reconstruction (R&R) Program. Through this effort, the agency aimed to: identify best practices for MODA in transportation; establish goals/objectives, measures, and metrics for a selected set of investments; develop prototype and baseline evaluation/trade-off analysis models; and identify process changes and training needs required to implement the research for prioritizing investments.

To achieve these objectives, the research team first performed a review of best practices and applications of MODA methods, including through interviews with peers with related prioritization approaches. Building on this foundation, the team collaborated with MDOT to develop a MODA-based approach for evaluating the target set of highway program assets and investment types at MDOT. The resulting prototype model includes 10 measures supporting the following four goals:

- Improve asset condition;
- Improve safety;
- Enhance accessibility and mobility; and
- Minimize adverse environmental impacts.

The research team tested the prototype model, using sample data provided by MDOT to evaluate and prioritize 39 R&R projects.

The implementation of the prototype model demonstrated how MODA can be used to evaluate and prioritize candidate projects within MDOT's R&R program. Initial results underscored the role of project cost and supplementary project components (e.g., safety, bike/pedestrian, or environmental activities) in differentiating between otherwise similar projects. Future efforts building on the research could include addressing any outstanding data limitations, implementing the approach with the completed dataset, evaluating its effectiveness, and adapting the approach to other MDOT programs with defined goals and measurable outcomes.

# 1. Introduction

## 1.1 Background

Transportation asset management (TAM) focuses on providing transportation agencies and other asset owners with tools and approaches for tracking what physical assets they have, such as roads, bridges and traffic and safety assets, and how best to invest in those assets to support their objectives. Transportation agencies use TAM to help establish what investments are needed in its physical assets, and how best to allocate scarce resources. Figure 1-1, reproduced from National Cooperative Highway Research Program (NCHRP) Report 921, illustrates the factors in the process, including investment levels, performance measures, and candidate investments, as well as key questions related to the different factors *(1)*.

Increasingly, transportation agencies are integrating data-driven, performance-based strategies into their resource allocation processes to support an improved approach to TAM. Multi-objective decision analysis (MODA) can provide a structured approach to this type of decision-making that incorporates a range of factors into transportation project selection. When using MODA, a transportation agency may apply a utility function to quantify how a candidate project may advance the agency's objectives, such as increasing safety, reducing congestion, or advancing equity. MODA enables decision-makers to evaluate and compare projects' potential contributions in each area, ultimately identifying and prioritizing investments that deliver the greatest impact toward an agency's objectives with the available funding.

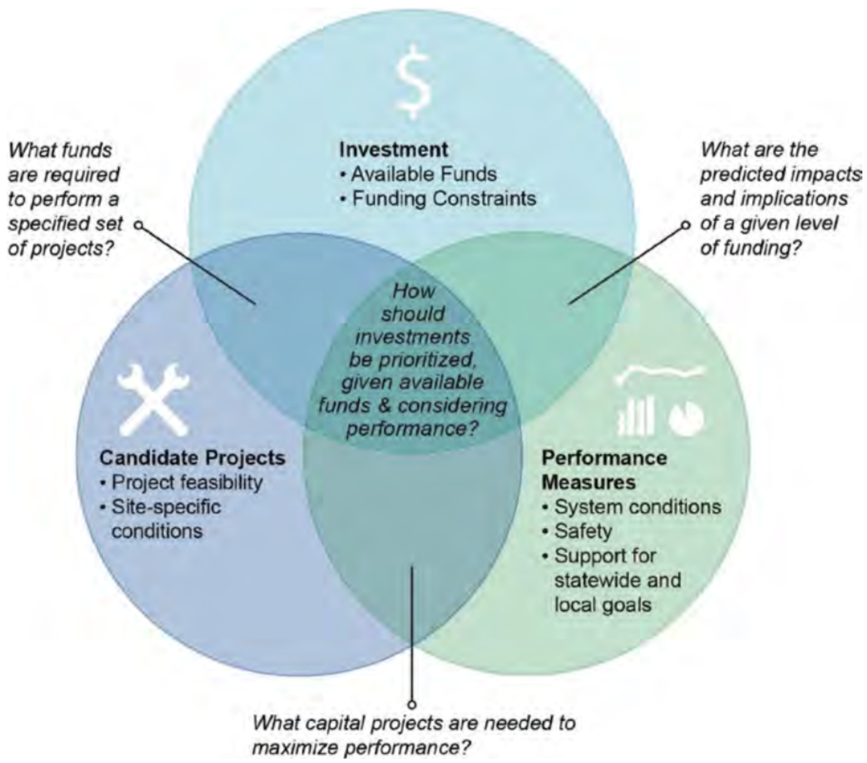


**Figure 1-1. Considerations for a Multi-Objective Resource Allocation (MODA) Process**
***Source: NCHRP Report 921***

## Objectives

The Michigan Department of Transportation (MDOT) sponsored research on the use of MODA in its Road Rehabilitation and Reconstruction (R&R) Program. The R&R program supports pavement improvement/restoration along the state's trunkline system, with the goal of maintaining the "highest sustainable system health possible with available resources" *(2).* The research lays the foundation for an improved resource allocation process within the R&R program, as well as explore the potential for leveraging MODA in other MDOT programs.

MDOT's objectives for the effort were to:

- Identify best practices for MODA in transportation;
- Establish goals/objectives, measures, and metrics for a selected set of investments;
- Develop prototype and baseline evaluation/trade-off analysis models; and
- Identify process changes and training needs required to implement the research for use in prioritizing investments.

## Scope

Spy Pond Partners, LLC (SPP) and Value Engineering LLC supported MDOT in researching the potential application of MODA, including through the development of a prototype model. The process of developing the MODA approach was organized according to the basic steps described in NCHRP Report 921 *(1)*, outlined in Figure 1-2.

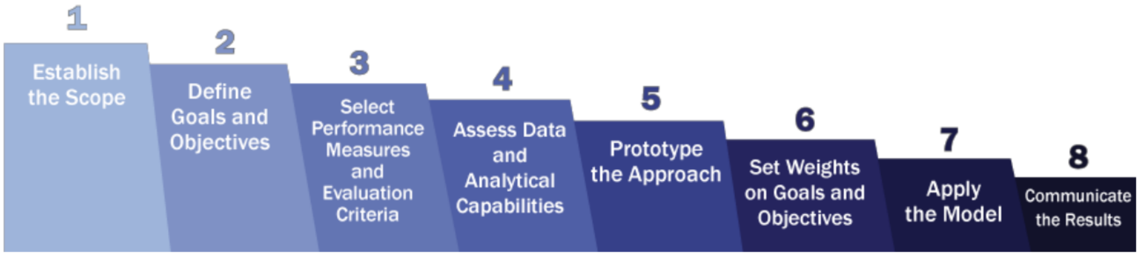


**Figure 1-2. Steps for Multi-Objective Resource Allocation (MODA) Implementation**

First, the research team performed a review of best practices and applications of MODA methods. This included a literature review, supplemented with a set of interviews with selected agencies that have implemented a MODA-based prioritization approach. Interviewed agencies are listed in Table 1-1.

**Table 1-1. Agency Interviews**

| Date | Organization | Interviewees |
|---|---|---|
| 6/21/24 | Vermont Agency of Transportation (VTrans) | • Ken Valentine, Asset Management Bureau Director |
| 6/24/24 | North Carolina Department of Transportation (NCDOT) | • Brian M. Wert, PE, Manager, Strategic Prioritization Office (SPOT) |
| 6/25/24 | Pennsylvania Department of Transportation (PennDOT) | • Justin Bruner, Bridge Asset Management (BAM) Section Chief in the Bureau of Maintenance and Operations, Highway Administration Deputate of PennDOT |
| 7/9/24 | Texas Department of Transportation (TxDOT) | • David Ford, Unified Transportation Program (UTP)/Portfolio Performance Director<br>• Eric Clennon, UTP Portfolio Manager<br>• Mildred Litchfield, Deputy Division Director, Transportation Planning and Programming |
| 7/10/24 | California Department of Transportation (Caltrans) | • Michael Johnson, State Asset Management Engineer |

Next, the research team built on the review findings to advance the research objective of establishing goals and measures for a selected set of highway program assets and investment types. The research team developed a set of draft goals and measures for use in MDOT's MODA process based on workgroup meetings with MDOT staff and reviews of related resources.

The research team then tested the proposed MODA approach. The team worked with MDOT to obtain data on test projects and implemented a prototype model using the sample data. The related activities and results are detailed in full in Section 4 below.

Throughout the process, the research team met with a workgroup of MDOT staff to review progress and solicit feedback, input, and questions. MDOT staff members consulted throughout the project are listed in Table 1-2. Meetings with MDOT staff are listed by date in Table 1-3.

**Table 1-2. MDOT Staff Members**

| Staff Member | Project Affiliation |
|---|---|
| Michael Case | Project Manager |
| Craig Newell | Focus Area Manager |
| Mary Hoffmeyer | Research Manager |
| Ben Dubois | MDOT Research Advisory Panel (RAP) |
| Rob Green | |
| Marjorie Zabel | |
| Magen Cole | |
| Beckie Curtis | |
| Margaret Szajner | |
| Lina Chapman | |
| Matt Lyle | |
| Faith Rodriguez | MDOT Research Administration (RAd) |
| Rebecca Petri | |
| Jennifer Herron | |
| Heidi Spangler | |
| Jon Engle | Subject Area Experts |
| Michael Eacker | |
| Edward Fowler | |
| Anita Boughner | |
| Bradley Sharlow | |

| Staff Member | Project Affiliation |
|---|---|
| Tim Lemon | |
| Kari Martin | |
| Brenda Kiesling | |
| Daniel Garcia | |
| Mike O'Malley | |
| Brad Peterson | |

**Table 1-3. Meetings with MDOT Staff**

| Date | Purpose |
|---|---|
| 3/13/2024 | Progress Meeting |
| 6/17/2024 | Progress Meeting |
| 8/12/2024 | Progress Meeting |
| 10/8/2024 | Pavement Condition Breakout Group |
| 10/23/2024 | Mobility Breakout Group |
| 10/24/2024 | Safety Breakout Group |
| 11/4/2024 | Progress Meeting |
| 2/3/2025 | Progress Meeting |
| 5/1/2025 | Progress Meeting |
| 6/23/2025 | Crash Data Access |
| 7/1/2025 | Environmental Improvements Inquiry |
| 7/10/2025 | Environmental Improvements Inquiry |

## 1.2 Report Organization

The remainder of this report is organized as follows:

- **Section 2** describes best practices and applications of MODA methods. This section compares examples of different transportation agencies' MODA-based prioritization approaches to MDOT's existing process within the R&R program.

- **Section 3** describes the prototype model for MODA project prioritization at MDOT. This section outlines the key process parameters, including its scope, goals, measures, and data requirements.
- **Section 4** details the implementation of the prototype model. This section includes information about the sample data, key assumptions, prototype model results, and implications for MODA use at MDOT, including considerations for expanded model implementation.
- **Section 5** provides an analysis of the prototype model results. This includes a comparison between the top-ranking projects and others, as well as a review of project points by goal area, variation in project ranks, and correlation among measures. The project team also discusses the limitations of the prototype approach.
- **Section 6** presents recommendations related to the further implementation of MODA at MDOT. This includes both the potential to extend the prototype model beyond the scope of the current analysis and opportunities for integration with other existing tools and processes at MDOT.
- The **Appendices** provide sample calculations, a description of the weighting workshop used to establish weights after the prototype model implementation, a review of updated results based on the established weights, and scoring spreadsheet tools for use in implementing the MODA model.

### References

1. Spy Pond Partners, LLC; High Street Consulting Group, LLC; and Burns & McDonnell. *NCHRP Report 921: Case Studies in Cross-Asset, Multi-Objective Resource Allocation*. National Academies Press, 2019.
2. Michigan Department of Transportation (MDOT). *Project Scoping Manual*, p. 2-11. MDOT, 2022.

# 2. Literature Review

This section provides an overview of the use of MODA to prioritize transportation investments. This includes an overview of different approaches to implementing MODA at transportation agencies, five case studies of agency MODA-based project prioritization approaches, and a comparison of MDOT's existing process for developing its transportation investment plan and parallel processes at peer agencies.

## 2.1 Review of Previous Research

### MODA Purpose

Every transportation agency considers a wide range of objectives when deciding how to invest in its physical assets. An agency tries to maintain its assets in good repair at minimum cost, while also considering factors such as how best to improve safety, what improvements may be needed to improve functionality or capacity, and how to address changing design standards, legal requirements, and performance targets, as well as other considerations. Many individual projects help support multiple objectives, combining the improvement of asset condition with safety, mobility, accessibility and/or environmental improvements.

In concept, asset management systems, such as pavement and bridge management systems, can help prioritize investments to achieve the best results considering limited funds. However, in practice, the different management systems use different approaches and assumptions for different asset classes (even when a single system supports multiple asset classes), complicating attempts at cross-asset, multi-objective prioritization. Also, management systems do not, as a rule, incorporate the full range of considerations that arise when scoping a project, such as the potential for introducing safety improvements to a pavement rehabilitation or reconstruction project.

MODA provides a structured approach for addressing this challenge. The term encompasses a variety of different approaches, and, in fact, a number of different terms are used to refer to the topic area. However, all of the different approaches have a common underlying premise: that a decision-maker may need to use a structured approach to choose between different discrete alternatives, weighing a range of different objectives that are difficult to compare to each other directly. Here, the application of MODA is specific to transportation investments, but the basic concepts can and have been applied to many different types of decisions.

### MODA Methods

MODA approaches vary in their aims and methods, both in practice and as described in related academic literature. For instance, in Analytical Hierarchy Practice (AHP), the aim is generally to maximize a value function, termed utility, that combines multiple objectives *(1)*. By contrast, in Data Envelopment Analysis (DEA), the aim is to maximize the achievement of different objectives, treating each objective separately without computing an overall utility *(2)*. In other approaches, the aim may be entirely different. Goal Programming *(3)* attempts to select alternatives that minimize the deviation from a specified set of performance goals. Robust Decision Making (RDM) identifies alternatives that perform best over a range of scenarios considering uncertainty in future conditions, selecting the alternative that minimizes regret *(4)*. This approach is commonly applied in areas with deep uncertainty, such as climate change mitigation. Another MODA variant is Fair Division, which selects alternatives that are perceived as fair and minimize envy between different stakeholders *(5)*.

The fact that so many different alternatives exist for MODA is indicative of the interest and potential for MODA approaches for supporting decision-making. At the same time, the sheer number of different approaches can make it challenging to determine which approach to implement. The following items provide guidance to practitioners seeking to identify the best MODA method for a specific context.

There is no one authoritative approach to implementing a MODA-based approach to support decision-making. Instead, there are many approaches that are based on different perspectives on how decisions are and should be made. The correct approach is the one that best aligns to an organization's desired approach and that yields projects that best move the organization toward its objectives.

Approaches such as AHP that attempt to maximize value are most common in related literature on the subject, and many of the processes currently in use at peer transportation agencies are based on an approach that implicitly or explicitly attempts to maximize overall value or utility. Other approaches reviewed in the literature typically have been applied to transportation investment prioritization in a limited manner, such as through a pilot or in a narrow application.

## MODA Application in Transportation

Increasingly, agencies are using MODA-based approaches to help prioritize investments. NCHRP Report 545 *(6)* documents that, by the early 2000s, there was already a clear need to prioritize across multiple objectives using a structured approach, but the existing cited tools that could support such a prioritization were economic models, such as the Federal Highway Administration (FHWA) Highway Economic Requirements System (HERS), used for modeling highway investment needs, and the National Bridge Investment Analysis System (NBIAS), used for modeling bridge needs. These tools model needs at a network level but are not designed to yield actionable project-level recommendations.

A decade later, NCHRP Report 806 *(7)* noted that a number of agencies had begun implementing the AHP for prioritizing investments considering multiple objectives and that commercial systems were available for supporting this approach. In the years following publication of NCHRP Report 806, additional agencies piloted or implemented MODA-based approaches using AHP or similar approaches, as documented in NCHRP Report 921 *(8)*. As of this time, most of the examples in the transportation field were based on AHP and were applied major capital works rather than capital preventive maintenance or operations and maintenance projects. However, the report includes several examples of agencies that either included consideration of asset needs in their prioritization or piloted a MODA approach for asset management projects.

## 2.1 Case Studies Illustrating MODA Applications

### Case Study 1: Vermont Agency of Transportation (VTrans)

VTrans has established the process Vermont Project Selection and Prioritization (VPSP2) to select projects that maximize the "transportation value" for the state's taxpayers for inclusion in VTrans' Capital Program *(9).* VTrans implemented the process once for paving, roadway, and traffic and safety projects, in 2021, and once for bridge projects, in 2022. The initial VPSP2 rounds selected several years' worth of projects, and, due to the large number of projects identified and prioritized during the initial rounds, VTrans has not needed to conduct additional scoring cycles.

VTrans' project identification process relies on management system recommendations and regional planning commission (RPC) input. First, VTrans evaluates program financial capacity, including anticipated and unallocated funding amounts. Second, VTrans conducts an exploratory analysis assuming 150% of the available capacity to identify a list of potential projects. Here, VTrans uses its pavement management system to develop the list of potential pavement projects and computes "transportation values" for each. Third, these "asset-driven" projects (so-called because they were derived from asset condition) are sent to RPCs. Fourth, the RPCs provide review and comments for asset-driven projects, along with proposals and scoring for projects of regional significance. In the initial VPSP2 rounds, approximately 20% of the scored projects were suggested by RPCs. Finally, VTrans compiles all RPC projects and scores and establishes a cutoff at 100% of the available financial capacity, beginning with the highest-scoring project and continuing down the list until the financial capacity is reached. Projects that fall below the threshold for inclusion may be considered in future rounds.

The VPSP2 process has eight scoring criteria: safety, asset condition, mobility and connectivity, economic access, resiliency, environment, community, and health access. The scoring process is primarily conducted internally via automated GIS processes and does not take into account the amount of available funding. In the initial round, pavement project scoring outcomes reflected strong alignment with VTrans' pavement system recommendations, and all VPSP2 asset-driven projects that were sent to RPCs were selected. Project scoring is not tied to funding.

#### Notable Features:

- VTrans has established a prioritization approach specific to pavement and bridge rehabilitation projects.
- VTrans' prioritization process relies on its management systems to identify projects for scoring. For pavement projects, VTrans uses pavement management system recommendations to determine the initial pool of projects for consideration; all of the projects considered for prioritization have been vetted via this initial analysis.

### Case Study 2: North Carolina Department of Transportation (NCDOT)

NCDOT uses a structured prioritization process to select projects for its State Transportation Improvement Program (STIP). This process is typically conducted every two years, and NCDOT has implemented the process seven times. The first two rounds were conducted for informational purposes, and the results of subsequent rounds have been used to drive programming decisions.

The process is used for capital projects across six modes: highway, bicycle and pedestrian, aviation, ferry, rail, and public transportation. However, prioritization is performed separately within each mode. To identify projects for scoring, NCDOT conducts a call for projects through which metropolitan planning organizations (MPOs), rural planning organizations (RPOs), and NCDOT highway divisions submit projects. The process has three funding tiers, each with its own eligibility and scoring parameters. These are as follows:

- **Division Needs:** funding is divided evenly among NCDOT's 14 transportation divisions and project scores are determined, in equal parts, by data and local priorities.
- **Regional Impact:** funding is allocated based on population to competitive processes within two transportation divisions, with 70 percent of project scores based on data and 30 percent based on local priorities.
- **Statewide Mobility:** project scores are based data alone *(10).*

The scoring process' criteria vary based on mode: highway criteria are determined by legislation, while a work group develops criteria for other modes. While the criteria vary by division, all include measures for statewide mobility (travel time cost/benefit, congestion, economic competitiveness, safety, and multi-modal (freight/military)); regional mobility (generally same as above and in some cases lane width and shoulder width); and division needs (generally the same criteria as regional, but weighted differently). Scoring is conducted via a spreadsheet tool, and the most recent scoring cycle evaluated approximately 2,800 projects. Selected projects are fully funded, though the entire funding amount may not be included within the STIP due to project timelines. NCDOT shares project scores, data, and selection information with applicants and the public online.

### Notable Features:

- For four programming cycles, NCDOT has used a comprehensive prioritization process to support programming decisions for major capital projects, including pavement rehabilitation or reconstruction projects.
- Project selection is based exclusively on project scores. However, the scoring process incorporates flexibility in various ways, including the use of division-specific weighting to reflect differing needs and priorities throughout the state.
- Prioritization process materials, including project scores and data, are shared publicly via NCDOT's website.

## Case Study 3: Pennsylvania Department of Transportation (PennDOT)

PennDOT is in the process of updating its approach to prioritizing and selecting asset management projects. This process supports the development of regional transportation improvement programs (TIPs) and the consolidated 12-year statewide plan. TIP updates are conducted every two years.

In the current process, PennDOT establishes funding guidance for each program category and for each of its MPO and RPO planning partners. PennDOT districts provide recommendations for pavement and bridge work to the MPOs and RPOs. The planning partners work collaboratively with the districts to develop their TIPs, using their preferred scoring or prioritization process for each district. Prioritization is performed separately for each funding category. However, pavement and bridge projects frequently include multiple types of work, such as safety and accessibility improvements, and, in some cases, may include funding from multiple funding categories.

One issue with the existing process is that, due to the variations in how prioritizations are performed from the various MPOs and PennDOT districts, there can be a disconnect between projects that address stakeholder preferences and those generated by the bridge and pavement management systems. As a result, PennDOT is currently developing a system called ProjectBuilder that recommends projects that integrate project recommendations from different sources, including stakeholder recommendations and pavement and bridge management system outputs. The system ranks projects recommended by stakeholders using a scoring approach that includes the goals in PennDOT's Statewide Long-Range Transportation Plan (SLRTP). The system calculates the economic benefits of these projects to support comparisons with the management system recommendations. With MPO/district projects scores converted to unified scoring mechanism, the system calculates the economic benefits of these projects to support comparisons with the management system recommendations. The system then recommends projects that maximize overall benefit subject to a budget constraint, integrating multiple types of work based on a set of business rules.

### Notable Features:

- PennDOT is in the process of developing and implementing a new approach to prioritizing and selecting asset management projects.
- In both the current and envisioned processes, scoring is conducted by PennDOT's planning partners, rather than at the statewide level.
- PennDOT's envisioned process will rely on its pavement and bridge management systems' recommendations to identify projects for consideration and add candidates for additional types of work to generate an optimized program of projects.

## Case Study 4: Texas Department of Transportation (TxDOT)

TxDOT uses a prioritization process to support the development of its 10-year Unified Transportation Program (UTP). The current iteration of the UTP has been in place since the early 2010s and includes 12 funding categories, which are defined by project type and selecting entity *(11).* The draft 2025 UTP includes a total of $104 billion in transportation projects over a 10-year period *(12).*

The process for each funding category varies. In some categories, for example, TxDOT allocates funding to its 25 districts, who then conduct separate processes. In others, TxDOT administers a call for projects with MPOs and districts collaborating on project submissions. For processes conducted at the district level, MPOs and districts determine their own approaches to performance-based prioritization, with scoring used as one component of decision-making.

Typically, the MODA approach is used for highway construction projects, which constitute the majority of projects. This process includes consideration of both needs-based scoring and projected performance, including items like congestion and connectivity, economic opportunity, and energy sector access *(11).* TxDOT's scoring process uses both DecisionLens, which is used for the initial analysis and to help set weights on different objectives, and an in-house platform, which compiles the necessary highway system and project scope data and conducts the scoring analysis.

TxDOT engages in a three-month process to finalize project selection decisions after district input is submitted, with the process soliciting feedback from the administration, state officials, and commission members. In addition to project scoring, factors considered in project selection include funding partnerships, project readiness, district priorities, and identification in other strategic initiatives. The scoring process is conducted annually, and the most recent round included approximately 1,200 projects.

### Notable Features:

- TxDOT's UTP development process includes both statewide and district-specific processes, with approaches varying across its 12 funding categories.
- TxDOT's current processes have been in place for more than 10 years and supports the development of a mid-range plan outlining, most recently, more than $100 billion in improvement investments.

## Case Study 5: California Department of Transportation (Caltrans)

Previously, Caltrans piloted a MODA approach for prioritizing asset management projects in its State Highway Operation and Protection Program (SHOPP). It has since revised its approach to reflect a performance-driven process that situates decision-making at the district level based on performance targets set at the state level. Caltrans adds new projects to the SHOPP every other year. Caltrans' SHOPP and maintenance programs reflect a total of $62.9 billion of investments over a 10-year period *(13).*

In the current process, Caltrans provides budgets and performance plans to each of its 12 districts. This guidance is informed by Caltrans' Statewide Highway System Management Plan, which presents an unconstrained needs assessment, a fiscally constrained investment plan, and district-level information across 33 performance objectives *(13).* District performance plans include both process benchmarks and performance metrics. In response, districts compile a portfolio of projects that address the performance plan within the assigned budget, prioritizing projects within the parameters set at the state level. In the future, Caltrans intends to offer MODA as a tool for evaluating projects at the district level.

### Notable Features:

- Caltrans conducted a MODA-based pilot and has since revised its approach to provide performance targets and budgets at the district level.
- The performance targeting approach is in production, but Caltrans is in the process of implementing the Transportation Asset Management System (TAMS) to improve the systems supporting the approach.
- As part of TAMS, Caltrans anticipates providing its districts with a tool that would support the use of MODA in their decision-making processes.

## 2.2 Comparison to MDOT's Existing Process

### Existing Process

MDOT details its planned capital investments in its Five-Year Transportation Program (5YTP) and updates this plan on an annual basis. The plan is informed by Michigan's 25-year SLRTP and Michigan's Transportation Asset Management Plan (TAMP). MDOT uses the 5YTP to prepare its federally-required STIP.

The basic process for updating the 5YTP is illustrated in Figure 3 and outlined below.

- **Estimate Revenue:** MDOT and the Michigan Department of Treasury estimate available funds from federal and state revenue sources.
- **Develop Investment Strategies:** MDOT staff develop and evaluate different scenarios for how transportation funds are allocated at a high level. These strategies focus on the baseline investment for programs included in the Highway Call for Projects (CFP) and how to potentially allocate additional remaining funds based on the most recent federal and state funding projections and any previous year obligations that exceeded available funding.
- **Call for Projects (CFP):** Using the selected investment strategy, MDOT's Statewide System Management Section (SSMS) issues funding targets, allocating MDOT's budget by project type. The CFP Approval Committee reviews and approves the funding targets. MDOT then allocates funding between regions based on an analysis of how best to achieve MDOT's performance targets performed using the Roadway Quality Forecasting System (RQFS) and Bridge Condition Forecasting System (BCFS). Finally, in the pavement programs, spending targets are set for each pavement tier. Once funding is established by project type and region, MDOT requests that its regions and program managers propose projects to add to the 5YTP subject to the funding constraints. Projects submitted by the regions are reviewed and approved by central office committees.
- **Develop Document:** MDOT prepares a draft document listing the projects proposed by regions and program managers.
- **Engage Stakeholders:** MDOT solicits feedback on the draft 5YTP from the public and MDOT's stakeholders.
- **Review and Finalize:** MDOT presents a draft of the 5YTP to the State Transportation Commission (STC) in the fall. MDOT then revises the 5YTP based on comments from the public, MDOT stakeholders, and STC. The finalized document is submitted to the Michigan legislature by March 1 of each year.

Currently, MDOT sets performance targets for percent of pavement in good or fair condition and provides each region with a budget for pavement rehabilitation and reconstruction. Separately, budgets are established for pavement capital preventive maintenance and other asset classes.

MDOT asks regions to consider the following when determining which pavement rehabilitation and reconstruction projects to perform: (1) RSL, (2) International Roughness Index (IRI), (3) Faulting, rutting, and cracking percent values (expressed as Pavement Condition Measure (PCM)), and (4)

Pavement Surface Evaluation and Rating (PASER). Regions have access to detailed condition data to support project data, and MDOT is in the process of developing a pavement management system (PMS) that will provide project recommendations. However, at present, MDOT does not have a formal process for prioritizing pavement rehabilitation and reconstruction projects generated through the CFP.

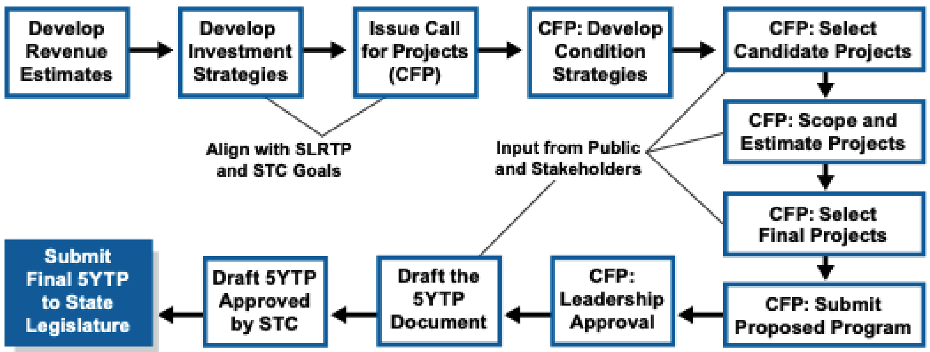


**Figure 2-1. MDOT Five-Year Transportation Program (5YTP) Update Process**
**Source: MDOT**

## Comparison to Alternative Approaches

In this section, three basic approaches for implementing MODA are defined for the purpose of comparison to MDOT's current process. All of these approaches start by defining a set of overall goals and objectives and then specifying measures that quantify how a proposed project will contribute to their achievement. All result in a selection of projects that is intended to inform, but not replace, human judgement concerning which projects to include in an agency's investment plan. And, all of the approaches can be tailored to utilize a range of specific tools and analytical approaches "under the hood." However, the approaches differ in key respects regarding how projects are generated and how measures are used.

The following three approaches are defined based on the case studies presented in Section 2: Core; Systems-Driven; and Performance-Based. These are described further below.

**Core.** With this approach, the agency defines a utility or scoring function that combines the consideration of multiple objectives. Projects are prioritized based on their score or score/cost ratio. The prioritization is performed separately by geographic area (e.g., by region or district). There may be differences among areas' prioritization approaches; they may use alternate weights on different objectives or incorporate local preferences as one of the measures. There are no specific requirements concerning how projects are generated. Instead, there are requirements concerning what projects are eligible for consideration.

This approach is similar to the process used by NCDOT and by TxDOT for portions of its UTP. Also, it is similar to the process used in many of the examples in the review where an MPO or DOT uses MODA to prioritize capacity expansion investments (as opposed to asset management investments).

The strength of the approach is that it is relatively straightforward and can be adapted as needed to accommodate additional types of projects or objectives. The weakness of the approach is that there is no direct link between project priorities and either the agency's performance targets or its asset life cycle strategies. Consequently, there is a risk that the project priorities resulting from this approach may fail to support the agency's performance targets and/or fail to reflect the asset life cycle strategies in its TAMP (such as by prioritizing using a simple, worst-first strategy).

**Systems-Driven.** This approach is similar to the Core Approach, but with one key difference: whereas the Core Approach places no particular constraints on how projects are generated, in the Systems-Driven Approach, projects are first generated using the agency's management systems. Alternatively, a set of potential projects could be proposed by applying a set of decision trees that are based on the agency's life cycle strategies.

This approach is similar to that used by VTrans for prioritizing pavement projects. Also, it is consistent with the approach PennDOT is currently developing for prioritizing pavement and bridge projects. In both of these cases, a project starts with a recommendation generated by the pavement or bridge management system. From there, a project engineer may add safety, accessibility, mobility, or other improvements to the project.

The strength of the Systems-Driven Approach is that it is guaranteed to generate projects that are consistent with the agency's life cycle strategies and management system recommendations, as it uses these to seed the list of projects that are considered in the first place. This limits the risk that the process will yield a set of projects at odds with the agency's approach to asset management. Also, the approach can be used to provide a comprehensive consideration of all the agency's asset needs. The weakness of the approach is that it requires robust management systems that generate project-level recommendations. Also, as in the case of the Core Approach, there is no direct tie to the agency's performance targets and, thus, a risk that the process will yield projects that fail to support the agency's targets.

**Performance-Based.** The final approach emphasizes achieving performance targets rather than prioritizing specific projects. As in the case of the Core Approach and Systems-Driven Approach (and any other MODA approach), the Performance-Based Approach starts with defining a set of measures that captures the objectives the agency or agencies seeks to achieve. However, in this approach, explicit targets are established for each measure. Stakeholders are then left to define and prioritize projects using whatever means they desire, provided the result achieves the specified performance targets. A scoring approach may be provided to assist in the prioritization process, but stakeholders are not required to use or abide by it.

This approach is similar to that used by Caltrans for prioritizing projects in its SHOPP. As discussed above, Caltrans piloted an approach similar to the Core Approach, but ultimately decided to give its districts flexibility to decide whether to use the scoring approach it developed or any other means to prioritize projects, provided the district achieves its performance targets.

The strength of the approach is that it provides stakeholders with increased flexibility in defining projects. Also, the approach tends to encourage cross-cutting projects that contribute to achieving multiple performance targets and maximizes the likelihood of obtaining a solution that meets those targets. The weakness of the approach is that it requires more work by stakeholders to generate potential projects and determine how to best meet the targets. Also, the approach is feasible only if other supporting processes are in place, such as processes facilitating the use of agency life cycle strategies.

Table 2-1 provides a comparison of the three idealized approaches to corresponding aspects of MDOT's current process.

**Table 2-1. Comparison of Alternative Approaches**

| | | Approach Requirements | | |
|---|---|---|---|---|
| **Process Components** | **Current MDOT Approach** | **Core** | **Systems-Driven** | **Performance-Based** |
| Defining investment goals and objectives | Defined in the 5YTP and planning documents | No change required – can use existing goals and objectives | | |
| Identifying measures for each objective | Asset condition and safety measures are defined | Additional measures needed for other objectives besides asset condition | | Additional measures and targets needed for quantifying work performed |
| Setting performance targets | Targets are established for asset condition and safety | Targets are not required, but can be used to set budgets by work type and/or region | | |
| Defining candidate projects | Regions propose projects in response to the CFP | No change required | Projects should be generated based on management systems | No change required |
| Quantifying measures for each project | Not currently performed | Change required – will need to introduce a process for performing this step | | |

| | | Approach Requirements | | |
|---|---|---|---|---|
| **Process Components** | **Current MDOT Approach** | **Core** | **Systems-Driven** | **Performance-Based** |
| Calculating project priorities | Regions use their own process for prioritizing | Change required – will need to introduce a process for performing this step | Change required – system prioritization tool would be needed. | No change required unless different performance targets are selected |

## References


1. Saaty, T. "Axiomatization of the Analytic Hierarchy Process." *Manage. Sci*., vol. 32, no. 7, pp. 841-855, 1986.
2. Charnes, A.; Cooper, W.; and Rhodes, E. "Measuring the Efficiency of Decision Making Units." *European Journal of Operational Research*, Vol. 2, No. 6, pp. 429-444, 1978.
3. Tamiz, M.; Jones, D.; and Romero, C. "Goal Programming for Decision Making: An Overview of the Current State-of-the-Art." *European Journal of Operational Research,* 111.3, 1998.
4. Lempert R.; Popper, S.; and Bankes, S. *Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis.* MR-1626-RPC. RAND, 2003.
5. Chang, C.; Taboada, H.; Espiritu, J.; Fullerton, T.; Montes, E.; and Walke, A. Using "Fair Division" *Methods for Allocating Transportation Funds.* Texas Department of Transportation, Research and Technology Implementation Office, 2013.
6. Cambridge Systematics, Inc.; PB Consult; and System Metrics Group, Inc. *NCHRP Report 545: Analytical Tools for Asset Management.* National Academies Press, 2005.
7. Maggiore, M.; Ford, K.; High Street Consulting Group; and Burns & McDonnell. *NCHRP Report 806: Guide to Cross-Asset Resource Allocation and the Impact on Transportation System Performance.* National Academies Press, 2015.
8. Spy Pond Partners, LLC; High Street Consulting Group, LLC; and Burns & McDonnell. *NCHRP Report 921: Case Studies in Cross-Asset, Multi-Objective Resource Allocation*. National Academies Press, 2019.
9. Vermont Agency of Transportation (VTrans). *Vermont Project Selection and Prioritization (VPSP2).* VTrans, n.d. Available at the following URL accessed July 30, 2024: https://vtrans.vermont.gov/project-selection.
10. North Carolina Department of Transportation (NCDOT). *Strategic Mobility Formula*. NCDOT, 2020. Available at the following URL accessed July 30, 2024: https://www.ncdot.gov/initiatives-policies/Transportation/stip/Pages/strategic-mobility-formula.aspx.

11. Texas Department of Transportation (TxDOT). *Funding Categories Descriptions: Unified Transportation Program*. TxDOT, n.d. Available at the following URL accessed July 30, 2024: https://ftp.txdot.gov/pub/txdot/get-involved/tpp/utp/061024-utp-funding-categories-descriptions.pdf.
12. TxDOT. *Unified Transportation Program: 2025*. TxDOT, n.d. Available at the following URL accessed July 30, 2024: https://ftp.txdot.gov/pub/txdot/get-involved/tpp/utp/070524-draft-2025utp.pdf.
13. California Department of Transportation (Caltrans). *Draft 2023 State Highway System Management Plan*. Caltrans, 2023. Available at the following URL accessed July 30, 2024: https://catc.ca.gov/-/media/ctc-media/documents/programs/shopp/2023-shsmp-draft.pdf.

# 3. Methodology

This section outlines the approach used to test the implementation of a MODA-based prioritization approach at MDOT. It illustrates the mechanics of the prototype model, including its scope, goals and objectives, measures of effectiveness, and method for calculating project scores. Sample calculations for all measures, as well as project-level scores and ranks, are provided in Appendix A.

## 3.1 Scope, Goals & Objectives

The prototype model is intended to evaluate pavement rehabilitation and reconstruction projects in support of MDOT's R&R program. The R&R program supports pavement preservation along the state's trunkline system.

The prototype model includes four high-level goals that are aligned with *Michigan Mobility 2045 (1)*:

- Improve asset condition
- Improve safety
- Enhance accessibility & mobility
- Minimize adverse environmental impacts

## 3.2 Measures of Effectiveness

The prototype model includes two or three measures of effectiveness (measures) for each goal area. These measures quantify a project's potential impact toward the related goal. They are listed in Table 3-1.

**Table 3-1. Prototype Model Measures of Effectiveness**

| Goal | Goal Description | Meas. | Measure Description |
|---|---|---|---|
| 1 | Improve asset condition | 1.1 | Change in remaining service life (RSL) |
| | | 1.2 | Increase in federal percent good |
| | | 1.3 | Reduction in federal percent poor |
| 2 | Improve safety | 2.1 | Anticipated crash reduction (lane departure) |
| | | 2.2 | Anticipated crash reduction (intersection improvement) |
| | | 2.3 | Anticipated crash reduction (vulnerable road user (VRU) safety improvement) |
| 3 | Enhance | 3.1 | Increase in bike & pedestrian accessibility |

| Goal | Goal Description | Meas. | Measure Description |
|---|---|---|---|
| | accessibility & mobility | | |
| | | 3.2 | Travel time savings |
| 4 | Minimize adverse environmental impacts | 4.1 | Fuel savings |
| | | 4.2 | Support for environmental commitments |

## Goal 1: Improve Asset Condition

Improving asset condition is consistent with the following goal articulated in *Michigan Mobility 2045*: to improve the condition of the state's transportation network in order to support "reliable," "resilient," and "adaptable" transportation across all modes (*1*). A project's anticipated impact on asset condition serves as a starting point for evaluating potential investments, with other goal areas capturing additional benefits that may serve to differentiate between two otherwise similar projects. The model includes three measures for quantifying projects' potential impact on asset condition. They build on MDOT's existing data and practices, including resources related to RSL and federal pavement performance measures.

### Measure 1.1: Change in Remaining Service Life (RSL)

RSL benefits are measured in terms of change in RSL for the project location, scaled by the extent of the project in lane miles. The variables used to calculate this measure are listed in Table 3-2.

**Table 3-2. Change in Remaining Service Life (RSL) Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Predominant fix type | Project engineer* | Fix type name |
| Lane miles | Project engineer | Number of lane miles |

*For the purposes of the prototype model, data items attributed to 'Project Engineer' were provided by the MDOT project lead or derived based on information from the MDOT project lead.

The measure calculation also uses established parameters for estimated fix life, as specified in MDOT's CFP manual *(2).*[1] When rehabilitation is recommended, the RSL is typically two years or less, so the fix life and added life are approximately equivalent. Further, the measure calculation incorporates the potential to apply one or more importance factors tied to the project location. These are listed in Table

[1] This measure draws on the 'Estimated Fix Life (added RSL years) from the 'Eligible Fix Types' table of MDOT's Highway Call for Projects: General Information and Program Instructions Manual.

3-3. For the purposes of the present research, all importance factor values are set to one; MDOT may define the relative value of each category in future applications of the MODA model.

**Table 3-3. Change in Remaining Service Life (RSL) Constants**

| Description | Value/Details |
|---|---|
| **Estimated fix life (years) by R&R project fix type** | |
| Repair existing & multiple course HMA overlay | 11 to 18 |
| Mill existing & multiple course HMA overlay | 11 to 18 |
| Concrete pavement patching | 6 to 10 |
| Concrete pavement restoration (patching, diamond grinding & joint resealing) | 9 to 14 |
| Crush & shape w/ multiple course HMA overlay | 19 |
| Rubbilize & multiple course HMA overlay | 16 |
| Asphalt stabilized crack relief layer w/ multiple course HMA overlay | 18 to 26 |
| Thin concrete overlay (<6") | 17 |
| Unbonded concrete overlay (≥6") | 19 |
| 6" + aggregate lift w/ multiple course HMA overlay | 18 |
| Hot mix asphalt reconstruction | 18 |
| Concrete reconstruction | 26 |
| **Route criticality factor** | |
| All projects | 1 |
| **Functional classification factor** | |
| Interstate | 1 |
| Other freeway | 1 |
| Other principal arterial | 1 |
| Minor arterial | 1 |
| Major collector | 1 |
| Minor collector | 1 |
| Local | 1 |
| **Geographic context factor** | |

| Description | Value/Details |
|---|---|
| Majority urban lane miles | 1 |
| Majority rural lane miles | 1 |

The calculation of the benefit associated with change in RSL is represented by Equation 1.

$$Benefit = L * Y * C * F * G \qquad (1)$$

Where:
*L* = lane miles
*Y* = estimated fix life (years) for predominant fix type*
*C* = route criticality factor
*F* = functional classification factor
*G* = geographic context factor

* For fix types with a range provided for estimated fix life (years), the average of the range minimum and maximum is used.

| Implementation Consideration |
|---|
| Within the prototype model, the calculation approaches for Measures 1.1: Change in Remaining Service Life (RSL), 1.2 Increase in Federal Percent Good, and 1.3: Reduction in Federal Percent Poor did not account for differences in route criticality, functional classification, or urban or rural geographic contexts for project locations. In implementing these measures, MDOT may consider applying scaling factors for each of these project location traits. |

### Measure 1.2: Increase in Federal Percent Good

Benefits for this measure are calculated by scaling the anticipated change in the percent of lane miles in good condition, as per FHWA pavement condition metrics, by the project size. The inclusion of this measure and Measure 1.3 enables MDOT to differentiate among projects with similar RSLs and/or similar benefits resulting from Measure 1.1. The variables used to calculate this measure are listed in Table 3-4.

**Table 3-4. Increase in Federal Percent Good Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Predominant fix type | Project engineer | Fix type name |
| Lane miles | Project engineer | Number of lane miles |
| Existing percent good* | MDOT | Percent lane miles |

| Description | Source | Units/Detail |
|---|---|---|
| Resulting percent good** | MDOT | Percent lane miles |

* This variable represents the percentage of 0.1-mile segments in good condition as calculated by MDOT.

**For the purposes of the prototype model, all fix types are assumed to result in 100 percent of lane miles in good condition.

The measure calculation also incorporates the potential to apply one or more importance factors tied to the project location based on route criticality, functional classification, and geographic context. These are consistent with the factors described for Measure 1.1 Change in Remaining Service Life (RSL) and listed in Table 3-3 above. As with Measure 1.1., for the purposes of the present research, all importance factor values are set to one; MDOT may define the relative value of each category in future applications of the MODA model.

The calculation of the benefit associated with the increase in federal percent good is represented by Equation 2.

$$Benefit = L * (PG2 - PG1) * C * F * G \quad (2)$$

Where:
*L* = lane miles
*PG1* = existing percent good
*PG2* = resulting percent good
*C* = route criticality factor
*F* = functional classification factor
*G* = geographic context factor

### Measure 1.3: Reduction in Federal Percent Poor

Benefits for this measure are calculated by scaling the anticipated change in the percent of lane miles in poor condition, as per FHWA pavement condition metrics, by the project size. The variables used to calculate this measure are listed in Table 3-5.

**Table 3-5. Reduction in Federal Percent Poor Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Predominant fix type | Project engineer | Fix type name |
| Lane miles | Project engineer | Number of lane miles |
| Existing percent poor* | MDOT | Percent lane miles |
| Resulting percent poor** | MDOT | Percent lane miles |

* This variable represents the percentage of 0.1-mile segments in poor condition as calculated by MDOT.

**For the purposes of the prototype model, all fix types are assumed to result in 0 percent of lane miles in poor condition.

The measure calculation also incorporates the potential to apply one or more importance factors tied to the project location based on route criticality, functional classification, and geographic context. These are consistent with the factors described for Measure 1.1 Change in Remaining Service Life (RSL) and listed in Table 3-3 above. As with Measure 1.1., for the purposes of the present research, all importance factor values are set to one; MDOT may define the relative value of each category in future applications of the MODA model.

The calculation of the benefit associated with the reduction in federal percent poor is represented by Equation 3.

$$Benefit = L * (PP1 - PP2) * C * F * G \tag{3}$$

Where:
*L* = lane miles
*PP1* = existing percent poor
*PP2* = resulting percent poor
*C* = route criticality factor
*F* = functional classification factor
*G* = geographic context factor

## Goal 2: Improve Safety

This goal reflects MDOT's commitment to enhancing the safety of the state's transportation network and, in particular, its supporting objective to reduce the number of fatalities and injuries sustained on the network (*1*). There are three measures used to quantify projects' potential safety impacts. They are focused on evaluating safety improvements commonly bundled with R&R projects, using historic crash data to calculate potential crash reductions for the project location.

### Measure 2.1: Anticipated Crash Reduction (Lane Departure)

Anticipated crash reduction benefits associated with lane departure safety improvements are determined by scaling the potential crash reduction associated with the improvement by the likelihood of the improvement's implementation. This measure's calculation relies on five-year historical crash data for the project location, from MDOT's Roadsoft database, with crashes broken out by crash type and severity. Implementation likelihood is based on whether the proposed project is consistent with existing plans and/or guidance, as indicated by the project engineer. Examples of potential resources that project engineers may draw on to determine the implementation likelihood include: regional Towards Zero Death (TZD) plans, high risk corridor research products, and MDOT's Road Safety Audit (RSA) program. The variables used to calculate this measure are listed in Table 3-6.

**Table 3-6. Anticipated Crash Reduction (Lane Departure) Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Implementation likelihood: Is the project likely to include a safety improvement to reduce lane departures? | Project engineer | Yes, it has been identified in a plan or as a matter of policy.<br>Maybe, improvement is under consideration but not identified in a plan or as a matter of policy.<br>No, improvement is not likely. |
| Number of crashes at project location in most recent five years | MDOT/Roadsoft | Crashes by type and severity |
| Project limits | Project engineer | Mile posts |

This measure's calculation also uses constants for: (1) weighting by crash severity, with fatalities receiving the greatest weight and property damage only crashes receiving the least; (2) a crash reduction factor for the lane departure improvement, identified via the FHWA Crash Modification Factors (CMF) Clearinghouse (*3*); and (3) scaling by the likelihood of the improvement's implementation, with the greatest likelihood associated with the highest coefficient. The measure calculation constants are listed in Table 3-7.

**Table 3-7. Anticipated Crash Reduction (Lane Departure) Constants**

| Description | Value/Detail |
|---|---:|
| **Implementation likelihood** | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |
| **Crash severity** | |
| Fatalities/fatal crashes | $12,500,000 |
| Serious injuries/serious injury crashes | $287,780 |
| Other crashes | $9,100 |
| **Crash Reduction Factor (CRF)** | |
| CRF value | 0.07 |
| Applicable crash types | Fixed object, sideswipe, head-on, overturn |

The calculation of the benefit associated with the anticipated crash reduction (lane departure) is represented by Equation 4.

$$Benefit = I * CRF * (CrashF * CostF + CrashI * CostI + CrashP * CostP) \quad (4)$$

Where:
*I* = implementation likelihood
*CRF* = crash reduction factor
*CrashF* = number of fatal crashes
*CostF* = cost per fatal crash
*CrashI* = number of injury crashes
*CostI* = cost per crash with injuries
*CrashP* = number of property damage only crashes
*CostP* = cost per property damage only crash

### Measure 2.2: Anticipated Crash Reduction (Intersection Improvement)

Anticipated crash reduction benefits associated with intersection improvements are calculated based on the approach described in Measure 2.1. The variables used for this calculation are consistent with those listed in Table 3-6. The constants used for this calculation are consistent with those listed in Table 3-7, with the exclusion of the crash reduction factor and applicable crash types, which are specific to intersection improvements. These are listed below in Table 3-8.

**Table 3-8. Anticipated Crash Reduction (Intersection Improvement) Constants**

| Description | Value/Detail |
|---|---|
| **CRF** | |
| CRF value | 0.27 |
| Applicable crash types | All intersection-related crashes |

### Measure 2.3: Anticipated Crash Reduction (Vulnerable Road User (VRU) Safety Improvement)

Anticipated crash reduction benefits associated with vulnerable road user (VRU) safety improvements are calculated based on the approach described in Measure 2.1. The variables used for this calculation are consistent with those listed in Table 3-6. The constants used for this calculation are consistent with those listed in Table 3-7, with the exclusion of the crash reduction factor and applicable crash types, which are specific to VRU safety improvements. These are listed below in Table 3-9.

**Table 3-9. Anticipated Crash Reduction (Vulnerable Road User (VRU)) Constants**

| Description | Value/Detail |
|---|---|
| **CRF** | |
| CRF value | 0.63 |

| Description | Value/Detail |
|---|---|
| Applicable crash types | All bike- or pedestrian-related crashes |

## Goal 3: Enhance Accessibility & Mobility

Enhancing accessibility and mobility aligns with MDOT's *Michigan Mobility 2045* goal to provide "efficient and effective operations and reliable multimodal opportunities" (*1*). Supporting objectives for this goal include providing "accessible and equitable modal options" and mitigating delays and congestion (*1*). There are two measures used to quantify projects' potential impact on accessibility and mobility. These incorporate consideration of both bike and pedestrian facilities (accessibility) and congestion reduction (mobility).

### Measure 3.1: Increase in Bike & Pedestrian Accessibility

Anticipated bike and pedestrian accessibility benefits are calculated based on the expected demand for proposed bike and pedestrian facilities. For bike facilities, the methodology for estimating demand is adapted from NCHRP Report 552 *(4).* With this approach, one first calculates the population in three buffer areas surrounding the proposed improvement: from 0 to ¼ mile, from ¼ to ½ mile, and from ½ to 1 mile. Next one predicts the portion of the population likely to cycle given the existing bicyclist commute share. This value is multiplied by a different multiplier for each buffer, and then multiplied by the population of the buffer area to yield the predicted number of new cyclists. It is important to note that, while cyclist commute share is an input, the model assumes that only a portion of bicycle trips are commute trips, and predicts new cyclists even if the cyclist commute share is 0%. The variables used to calculate this measure are listed in Table 3-10. The table references the "primary geography" for the project. This is the surrounding area is the county or municipality with the greatest share of the project area.

For pedestrian facilities, the methodology for estimating demand is based on the Transportation Evaluation and Carbon Reduction Tool (TEA-CART) approach from the Georgetown Climate Center *(5).* The model predicts new pedestrian demand given the length of the corridor improved and population density. The documentation for the model details calculations for four specific population densities; a linear model was fit to allow for variation in the predictions by population density.

**Table 3-10. Increase in Bike & Pedestrian Accessibility Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Implementation likelihood: Is the proposed project likely to include pedestrian facility improvement? | Project engineer | Yes, it has been identified in a plan or as a matter of policy.<br>Maybe, improvement is under consideration but not identified in a plan or as a matter of policy.<br>No, improvement is not likely |

| Description | Source | Units/Detail |
|---|---|---|
| Implementation likelihood: Is the proposed project likely to include bike facility improvement? | Project engineer | Yes, it has been identified in a plan or as a matter of policy.<br>Maybe, improvement is under consideration but not identified in a plan or as a matter of policy.<br>No, improvement is not likely. |
| Project limits | Project engineer | Mile posts |

The calculations for this measure use parameters derived from U.S. Census Bureau American Community Survey (ACS) data on the population density and cyclist commute share of the proposed project's primary geography; constants for scaling by the likelihood of implementation, with the greatest likelihood associated with the highest coefficient; and additional calculation parameters based on the NCHRP and TEA-CART methodologies. These are listed in Table 3-11.

**Table 3-11. Increase in Bike & Pedestrian Accessibility Constants & Parameters**

| Description | Value/Detail |
|---|---:|
| Population density of primary geography | People/square mile (Based on ACS data) |
| Cyclist commute share of primary geography | Percent of workers aged 16 and over (Based on ACS data) |
| **Implementation likelihood** | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |
| Buffer 1 (miles) | 0.25 |
| Buffer 2 (miles) | 0.50 |
| Buffer 3 (miles) | 1.00 |
| Existing bike rate intercept | 0.3% |
| Existing bike rate slope | 0.96 |
| New bicyclist demand multiplier, Buffer 1 | 1.93 |
| New bicyclist demand multiplier, Buffer 2 | 1.11 |

| Description | Value/Detail |
|---|---|
| New bicyclist demand multiplier, Buffer 3 | 0.39 |
| New pedestrian minimum | 0.18% |
| New pedestrian maximum | 2.27% |
| New pedestrian slope | 0.00022% |
| New pedestrian intercept | 0.07% |

The calculation of the benefit associated with an increase in bike and pedestrian accessibility is represented by Equation 5.

$$Benefit = IB * (BI + BS * C) * (B1 * BD1 + B2 * BD2 + B3 * BD3) + IP * MIN(PX, MAX(PN, PI + PS*P)) * B1 \quad (5)$$

where:
*IB* = Implementation likelihood for bike facility
*IP* = Implementation likelihood for pedestrian facility
*BI* = Intercept of the bicyclist demand curve
*BS* = Slope of the bicyclist demand curve
*C* = Bicyclist commute share
*B1* = Population of Buffer 1 (0.00 – 0.25 miles from the corridor)
*B2* = Population of Buffer 2 (0.25 – 0.50 miles from the corridor)
*B3* = Population of Buffer 3 (0.50 – 1.00 miles from the corridor)
*BD1* = New bicyclist demand multiplier for Buffer 1
*BD2* = New bicyclist demand multiplier for Buffer 2
*BD3* = New bicyclist demand multiplier for Buffer 3
*PX* = Maximum new pedestrians as a percent of the population
*PN* = Minimum new pedestrians as a percent of the population
*PI* = Intercept of the pedestrian demand curve
*PS* = Slope of the pedestrian demand curve
*P* = Population density

| Implementation Consideration |
| --- |
| Within the prototype model, the calculation approach for Measure 3.1: Increase in Bike & Pedestrian Accessibility did not differentiate between different types of bike or pedestrian facility improvements. However, bike or pedestrian facility improvements may vary in their degree of impact on bike or pedestrian demand, alignment with MDOT priorities, or use in different geographic contexts. A painted shared lane marking, for example, may induce fewer bike trips than a new shared use path; a shoulder widening, for its part, may qualify as a bike/pedestrian improvement in rural contexts, but not in cities. In implementing this measure, MDOT may consider accounting for variances in impact by facility type or context. This would require additional project data related to the proposed improvements. |

### Measure 3.2: Travel Time Savings

Anticipated travel time savings are based on the estimated congestion reduction resulting from the project. The project engineer indicates the degree to which the project will reduce congestion by selecting one of three potential descriptions of the project, which combine anticipated impact and implementation likelihood: (1) The project will reduce congestion and is part of an existing plan; (2) The project may reduce congestion; (3) The project is not expected to reduce congestion. The variables used to calculate this measure are listed in Table 3-12.

**Table 3-12. Travel Time Savings Variables**

| Description | Source | Units/Detail |
| --- | --- | --- |
| Congestion reduction likelihood: To what extent is the project expected to reduce congestion? | Project engineer | (1) The project will reduce congestion and is part of an existing plan.<br>(2) The project may reduce congestion but is not included in an existing plan for congestion reduction.<br>(3) The project is not expected to reduce congestion. |
| Project limits | Project engineer | Mile posts |
| Project location VMT | MDOT | VMT |

The calculation uses constants associated with levels of congestion reduction likelihood, with the greatest likelihood associated with the highest coefficient. These are listed in Table 3-13.

**Table 3-13. Travel Time Savings Constants**

| Description | Value |
|---|---|
| **Congestion reduction likelihood** | |
| The project will reduce congestion and is part of an existing plan. | 1.00 |
| The project may reduce congestion but is not included in an existing plan for congestion reduction. | 0.50 |
| The project is not expected to reduce congestion. | 0.00 |

The calculation of the benefit associated with travel time savings is represented by Equation 6.

$$Benefit = I * VMT \tag{6}$$

Where:
*I* = congestion reduction likelihood
*VMT* = project location VMT

| Implementation Consideration |
|---|
| To implement the prototype model approach, project engineers may consider the following factors to determine a project's congestion reduction likelihood: percent unreliable vehicle miles traveled (VMT), bottleneck miles, congestion miles, and/or degree of improvement. Alternatively, MDOT may consider replacing the Congestion Reduction Likelihood variable with a direct estimate of a project's anticipated travel time savings if modeling tools are available to support the assessment. The primary benefit of this approach is a more granular assessment of projects' potential impacts; the primary drawback is the need for greater resources to support project-specific congestion reduction analyses. |

## Goal 4: Minimize Adverse Environmental Impacts

Minimizing adverse environmental impacts aligns with the *Michigan Mobility 2045* objective to "[p]lan, develop, and maintain transportation facilities in a manner that protects the natural, historic, and cultural environment and avoids or minimizes adverse impacts" (*1*). There are two proposed measures for quantifying projects' potential to minimize adverse environmental impacts. They capture both a project's impact on fuel consumption, as well as a project's support for MDOT's broader environmental commitments, capturing a wider range of additional environmental enhancements that may be coupled with pavement projects.

### Measure 4.1: Fuel Savings

Anticipated fuel savings are based on estimated congestion reduction and change in pavement smoothness. The estimated congestion reduction is determined in Measure 3.2. The International Roughness Index (IRI) is used to measure pavement smoothness. The approach to estimating fuel savings resulting from change in pavement smoothness is based on that detailed in NCHRP Report 720 *(6).* The variables used to calculate this measure are listed in Table 3-14.

**Table 3-14. Fuel Savings Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Project limits | Project engineer | Mile posts |
| Existing pavement smoothness | MDOT | IRI |
| Project location VMT | MDOT | VMT |
| Congestion reduction likelihood: To what extent is the project expected to reduce congestion? | Project engineer | (1) The project will reduce congestion and is part of an existing plan.<br>(2) The project may reduce congestion but is not included in an existing plan for congestion reduction.<br>(3) The project is not expected to reduce congestion. |

The calculation uses constants associated with each level of congestion reduction likelihood, with the greatest likelihood associated with the highest coefficient. These are consistent with those used in Measure 3.2 and listed in Table 3-13 above. The calculation also uses three addition constants, listed in Table 3-15.

**Table 3-15. Fuel Savings Constants**

| Description | Value |
|---|---:|
| IRI2: assumed IRI for smooth pavement | 76.0 |
| R: 63.4 (conversion of IRI to metric units) / 1.6% (reduction for each meter/kilometer change in IRI)* | 3,962.5 |
| FC: typical reduction in fuel consumption for an R&R project with a congestion reduction improvement (hours/car)* | 0.01 |

* NCHRP 720 value converted from metric to English units.

The calculation of the benefit associated with fuel savings is represented by Equation 7.

$$Benefit = (((IRI1 - IRI2)\,/\,R) + I * FC\,) * VMT \tag{7}$$

Where:

*I* = implementation likelihood
*IRI1* = existing IRI
*IRI2* = IRI for smooth pavement
*VMT* = VMT at project location
*R* = percent reduction in fuel consumption per unit change in IRI
*FC* = typical reduction in fuel consumption for an R&R project with a congestion reduction improvement (hours/car)

### Measure 4.2: Support for Environmental Commitments

Projects can receive credit for activities that support MDOT's environmental commitments, including both regulatory and voluntary activities. The support for environmental commitments benefit is based on the extent of the associated environmental activities, such as treated land area or wetland area. The variables used to calculate this measure are listed in Table 3-16. If the project includes multiple activities that support MDOT's environmental commitments, benefits are calculated for each activity and then summed.

Examples activities that would support MDOT's environmental commitments include:

- **Wetland activities** – This may include culvert improvements, the planting of native vegetation, and/or the mitigation of non-native species. In these instances, the extent of the activity is equal to the area (acres) of all wetlands affected by the wetland activities associated with the pavement rehabilitation or reconstruction project.
- **Noise abatement** – This may include the installation of noise walls targeting the reduction of motor vehicle noise (*7).* For this type of improvement, the extent of the activity would be the area (acres) affected by the noise wall, derived from the length of the wall and an associated buffer distance.
- **Protected species habitat management** – This may include the creation of pollinator migratory corridors, biological controls to combat non-native species, the planting of native flowering plants (*8*), as well as activities related to other protected species. In these instances, the extent of the activity would be the land area (acres) of the migratory corridor, the habitat protected through the biological control technique, or the plantings of native flowering species.

**Table 3-16. Support for Environmental Commitments Variables**

| Description | Source | Units/Detail |
|---|---|---|
| Implementation likelihood: Does the proposed project include an activity that supports MDOT's environmental commitments?* | Project engineer | Yes, it includes an activity that supports MDOT's environmental commitments.<br>Maybe, it is under consideration.<br>No, it does not include an activity that supports MDOT's environmental commitments. |

| Description | Source | Units/Detail |
|---|---|---|
| Extent of activity** | Project engineer | Acres |
| Type of activity** | Project engineer | Description of the activity that supports MDOT's environmental commitments |

* Activities required for regulatory compliance automatically receive the highest level of implementation likelihood.

**Required only if improvement likelihood is "Yes" or "Maybe."

This calculation of this measure relies on constants for scaling the benefit in accordance with its implementation likelihood, with the greatest likelihood associated with the highest coefficient. These are listed in Table 3-17.

**Table 3-17. Support for Environmental Commitments Constants**

| Description | Value |
|---|---|
| **Implementation likelihood** | |
| Yes, it includes an activity that supports MDOT's environmental commitments. | 1.00 |
| Maybe, it is under consideration. | 0.50 |
| No, it does not include an activity that supports MDOT's environmental commitments. | 0.00 |

The calculation of the benefit associated with support for environmental commitments is represented by Equation 8.

$$Benefit = (I1 * A1) + (I2 * A2) + (I3 + A3) \quad (8)$$

Where:
*I1* = implementation likelihood for the first activity
*A1* = extent of activity for the first activity
*I2* = implementation likelihood for the second activity
*A2* = extent of activity for the second activity
*I3* = implementation likelihood for the third activity
*A3* = extent of activity for the third activity

The provided equation may be adapted to incorporate the total number of activities within the project.

| Implementation Consideration |
| --- |
| Within the prototype model, the calculation approach for Measure 4.2 Support for Environmental Commitments used references to culvert or drainage improvements as a starting point for identifying potential activities in support of MDOT's environmental commitments to support the aim of testing the evaluation approach. The locations of projects with culvert or drainage work were compared to the locations of wetlands in the National Wetlands Inventory to identify potential wetland activities. For future research or implementation efforts, results would be strengthened by more detailed project-level data, as applicable, on the type and extent of activities supporting MDOT's environmental commitments. |

## 3.3 Project Score Calculation

For each candidate project, the measures outlined above yield a range of values associated with different anticipated benefits and across different unit types. To facilitate comparisons across measure areas and the calculation of combined goal and project scores, individual measure scores are converted to a scale of 0 to 100, with the top-performing project for each measure receiving a score of 100 and other projects scored proportionately. The scaled measure scores are then multiplied by a set of weights and aggregated at the goal level as goal scores. The project's goal scores are then multiplied by corresponding weights specific to each goal and combined into a total project score. This process is illustrated in Figure 3-1.

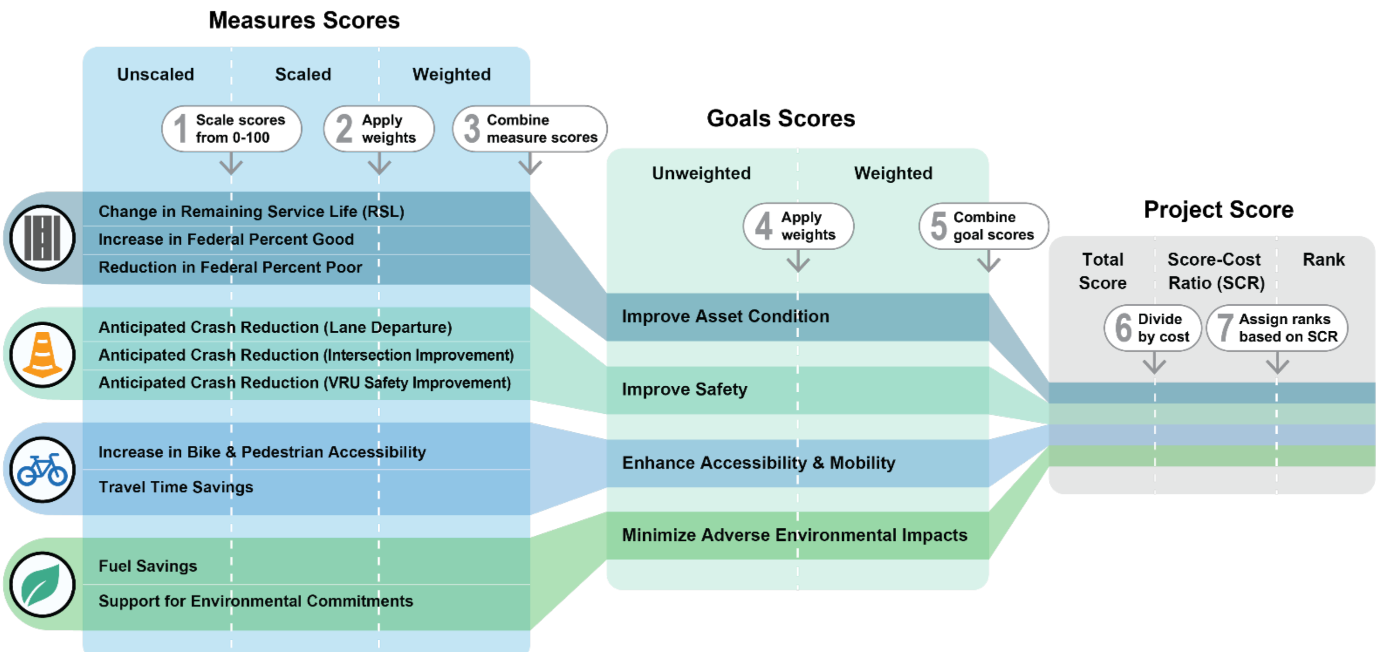


**Figure 3-1. Project Score Calculation**

Lastly, project scores are divided by project costs to determine the relative value of the proposed project, or its cost effectiveness. This ratio, called the score-cost ratio (SCR), serves as the core tool for comparing and prioritizing projects.

For the purposes of the initial implementation of the prototype model, each goal area was weighted equally. Final measure and goal weights were set by MDOT stakeholders in accordance with the agency's priorities. The weights for each measure, or their shares of the total project score, are listed in Table 3-18.

**Table 3-18. Weights by Measure**

| Measure | Weight |
|---|---|
| **Goal 1: Improve asset condition** | |
| 1.1: Change in RSL | 8.33% |
| 1.2: Increase in federal percent good | 8.33% |
| 1.3: Reduction in federal percent poor | 8.33% |
| **Goal 2: Improve safety** | |
| 2.1: Anticipated crash reduction (lane departure) | 8.33% |
| 2.2: Anticipated crash reduction (intersection improvement) | 8.33% |
| 2.3: Anticipated crash reduction (VRU safety improvement) | 8.33% |
| **Goal 3: Enhance accessibility & mobility** | |
| 3.1: Increase in bike & pedestrian accessibility | 12.50% |
| 3.2: Travel time savings | 12.50% |
| **Goal 4: Minimize adverse environmental impacts** | |
| 4.1 Fuel savings | 12.50% |
| 4.2 Support for environmental commitments | 12.50% |

## References


1. MDOT. *Michigan Mobility 2045.* MDOT, 2021.
2. MDOT. [2026 – 2030] *Highway Call for Projects: General Information and Program Instructions Manual.* MDOT, n.d.
3. Federal Highway Administration (FHWA). *Crash Modification Factors Clearinghouse*. FHWA, n.d.

4. Georgetown Climate Center & Cambridge Systematics Inc. *Transportation Evaluation and Carbon Reduction Tool (TEA-CART).* 2025. https://www.georgetownclimate.org/files/TEA-CART-User-Guide-and-Methodology_Nov-2025.pdf
5. Krizek, K. *NCHRP Report 552: Guidelines for Analysis of Investments in Bicycle Facilities.* National Academies Press, 2006.
6. Chatti, K.; and Zaabar, I. *NCHRP Report 720: Estimating the Effects of Pavement Condition on Vehicle Operating Costs.* National Academies Press, 2012.
7. MDOT. *Noise abatement.* MDOT, n.d. https://www.michigan.gov/mdot/programs/highway-programs/environmental-efforts/noise-abatement.
8. MDOT. Pollinator Habitat Management. MDOT, n.d. https://www.michigan.gov/mdot/programs/highway-programs/roadside-property-management/pollinator-habitat-management-program.

# 4. Findings

This section provides a description of how the prototype model was implemented and the corresponding initial results. It includes information about the data used, key assumptions, initial results, and implications for MODA use at MDOT.

## 4.1 Summary of Data

### Project Data

To support implementation of the prototype model, MDOT provided data for 39 pavement rehabilitation and reconstruction projects that were submitted as part of its 2026-2030 CFP. The sample projects reflected a range in project sizes, locations, and fix types, with an average project cost of $18.5 million (minimum: $920K, maximum: $251M) and an average project length of 4.0 miles (minimum: 0.4 miles, maximum: 11.7 miles). There were 25 counties represented among the sample project cohort, with 18 urban projects and 21 rural projects. The sample projects are listed in Appendix D as part of the scoring tools.

MDOT also provided separate information on the 276 individual treatments that made up the test projects; the project- and treatment-level data were associated using a shared job number field. Treatments range in length from less than a one thousandth of a mile to 8.2 miles, with an average length of 0.8 miles. The number of treatments per project range from one to 67, with an average of 7.1 treatments per project. The project with the greatest number of treatments is 211181-M-10-Wayne County, a concrete pavement repair project extending from Meyers to I-75. The majority of projects (17 out of 39) have only one or two treatments.

These datasets included key project attributes required for the implementation of the prototype model. These are listed in Table 4-1.

**Table 4-1 Project Attributes**

| Attribute | Treatment Level | Project Level |
|---|---|---|
| Job number | X | X |
| Route | X | X |
| Limits | | X |
| Work description | | X |
| Total job budget | | X |
| Lane miles | X | X |

| Attribute | Treatment Level | Project Level |
|---|---|---|
| Segment length | X | |
| Ramp | X | |
| IRI | X | |
| Percent good latest avg PCM | | X |
| Percent poor latest avg PCM | | X |
| 2023 weighted average AADT | X | |
| 5-year crash data (severity, type) | | X |

## Crash Data

To support the calculation of the measures in the safety goal area, the MDOT Safety Programs Unit provided available five-year historic crash data for the 17 projects identified as including safety improvements with provided work descriptions indicating the inclusion of safety improvements. The crash data were pulled from MDOT's Roadsoft system. It included crash data for 2020-2024, with data fields for each crash including crash type, crash severity, number of fatalities, number of injuries, whether the crash involved cyclists, whether the crash involved pedestrians, and whether the crash was inter-section related. The crash data did not include wildlife incidents.

The project team also accessed the equivalent crash data from Michigan Traffic Crash Facts (MTCF) for one project (JN: 211155, Location: US-23 N, from M-14 to I-94) for which additional MDOT materials indicated the inclusion of safety improvements.

## Data Processing & Assumptions

The research team processed the provided project and crash data for use within the prototype model. This included both deriving scoring inputs from the provided data, such as determining the VMT for a project corridor based on the provided average annual daily traffic for its individual treatments, as well as applying several informed assumptions to address data gaps. These assumptions are listed for each scoring input by measure below. Additional information about how each input is used in measure calculations is available in Section 3. In future applications of the MODA model, these gaps could be addressed by more detailed project information. Related recommendations are listed in Section 4.3. The full set of parameters used in the prototype model are provided in the scoring tools in Appendix D.

### Measure 1.1. Change in Remaining Service Life (RSL)

- *Predominant fix type:* The predominant fix type was derived from the project work description.
- *Route criticality factor, functional classification factor, and geographic context factor:* All factor values were set to one, providing a placeholder for MDOT to establish values that capture the relative value of each category in the future.

### Measure 1.2 Increase in federal percent good

- *Anticipated federal percent good:* All projects were assumed to produce 100%.
- *Predominant fix type*: See above.
- *Route criticality factor, functional classification factor, and geographic context factor:* See above.

### Measure 1.3 Reduction in federal percent poor

- *Anticipated federal percent poor:* All projects were assumed to produce 0% poor.
- *Predominant fix type*: See above.
- *Route criticality factor, functional classification factor, and geographic context factor:* See above.

### Measure 2.1 Anticipated crash reduction (lane departure)

- *Implementation likelihood:* The implementation likelihood was derived from the project work description. If the description referenced a shoulder, guardrail, or unspecified safety improvement, it was assigned an implementation likelihood of 'Yes' (value = 1). If the project work description did not include such a reference, it was assigned an implementation likelihood of 'No' (value = 0). No projects were assigned an implementation likelihood of 'Maybe' (value = 0.5).

### Measure 2.2 Anticipated crash reduction (intersection improvement)

- *Implementation likelihood:* The implementation likelihood was derived from the project work description. If the description referenced an intersection reconstruction, it was assigned an implementation likelihood of 'Yes' (value = 1). If the project work description did not include such a reference, it was assigned an implementation likelihood of 'No' (value = 0). No projects were assigned an implementation likelihood of 'Maybe' (value = 0.5).

### Measure 2.3 Anticipated crash reduction (vulnerable road user (VRU) safety improvement)

- *Implementation likelihood:* The implementation likelihood was derived from the project work description. If the description referenced ADA ramp, sidewalk, or bike infrastructure improvements, it was assigned an implementation likelihood of 'Yes' (value = 1). If the project work description did not include such a reference, it was assigned an implementation likelihood of 'No' (value = 0). No projects were assigned an implementation likelihood of 'Maybe' (value = 0.5). Note that no project work descriptions within the sample dataset referenced bike infrastructure.

### Measure 3.2: Travel time savings

- *Congestion reduction likelihood:* The congestion reduction likelihood was derived from the project work description. If the description referenced operational improvements (e.g., interchange reconstruction, traffic signal modernization, lane conversion), it was assigned an implementation likelihood of 'Yes' (value = 1). If the project work description did not include such a reference, it was assigned an implementation likelihood of 'No' (value = 0). No projects were assigned an implementation likelihood of 'Maybe' (value = 0.5).

### Measure 4.2 Support for environmental commitments

- *Implementation likelihood:* The implementation likelihood was derived from the project work description. Project work descriptions did not explicitly reference the full extent of a project's support for MDOT's environmental commitments. Select work descriptions referenced culvert or drainage improvements but did not specify the number, location, or wetland impact of a project's culvert or drainage improvements. For each project with these improvements, the research team reviewed the project corridor to identify likely culvert or drainage locations that spanned the wetlands areas included in the National Wetlands Inventory *(2).* If a project had a likely culvert or drainage location that spanned a wetland area, it was assigned an implementation likelihood of 'Yes' (value = 1). All other projects were assigned an implementation likelihood of 'No' (value = 0). No projects were assigned an implementation likelihood of 'Maybe' (value = 0.5). Note that the research team was not able to identify any culvert or drainage improvement locations likely to affect designated wetland areas for select projects with work descriptions referencing these types of improvements. For these projects, the assigned implementation likelihood was 'No.'
- *Extent of activity:* For projects with likely culvert or drainage locations that spanned wetland areas, these locations were tallied to produce the assumed number of culvert or drainage improvement locations that could serve as a proxy for wetland activities in support of MDOT's environmental commitments. The extent (acres) of the wetland activities benefit was equal to the number of these locations, multiplied by a constant of 2 acres per culvert or drainage improvement location. This same constant was applied to all potential improvement locations.

## 4.2 Prototype Model Results

### Project Scores & Rankings

The project priorities generated by the prototype model are listed by rank, from highest to lowest priority, in Table 4-2. These ranks are based on projects' overall SCR. In the initial application of the prototype model, each goal was weighted equally (Section 3.3). Additional details about each candidate project are provided in Appendix D. A map of the test projects is included in Figure 4-1. Measure and goal weights were subsequently set by MDOT stakeholders in accordance with the agency's priorities in the final phase of the research effort. The process used to determined weights, the updated weighting schema, and revised scoring results based on the updated weighting schema are provided in the appendices.

**Table 4-2. Prototype Model Priorities**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| ***Top 10 Projects*** | | | | |
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 4.67 | 1 |
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 3.63 | 2 |
| 210168-M-20-Isabella County | Bay | $3,779,560 | 2.03 | 3 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 1.97 | 4 |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 1.64 | 5 |
| 209212-M-29-St. Clair County | Bay | $5,981,018 | 1.60 | 6 |
| 214169-US-31 BR-Muskegon County | Grand | $2,062,000 | 1.55 | 7 |
| 211421-M-142-Huron County | Bay | $1,823,201 | 1.53 | 8 |
| 207968-US-31 BR-Oceana County | Grand | $8,475,000 | 1.21 | 9 |
| 213157-US-31 NB-Ottawa County | Grand | $3,600,000 | 1.08 | 10 |
| ***Other Projects*** | | | | |
| 209082-US-127-Clare County | Bay | $17,591,949 | 0.96 | 11 |
| 200682-US-31-Mason County | Grand | $6,810,000 | 0.89 | 12 |
| 120048-M-85-Wayne County | Metro | $11,965,000 | 0.85 | 13 |
| 211012-M-28-Alger County | Superior | $14,090,000 | 0.77 | 14 |
| 208891-US-41-Alger County | Superior | $8,525,405 | 0.75 | 15 |
| 208803-US-45-Gogebic County | Superior | $7,091,000 | 0.68 | 16 |
| 216348-US-31-Ottawa County | Grand | $6,665,000 | 0.65 | 17 |
| 204355-M-53-Lapeer County | Bay | $5,922,666 | 0.62 | 18 |
| 211173-I-96-Muskegon County | Grand | $23,186,000 | 0.61 | 19 |
| 217178-US-2-Mackinac County | Superior | $9,082,900 | 0.59 | 20 |
| 210819-M-66-Barry County | Grand | $1,258,000 | 0.58 | 21 |
| 201143-US-131 SB-Osceola County | Grand | $6,813,000 | 0.58 | 22 |
| 213791-I-75-Genesee County | Bay | $39,305,339 | 0.57 | 23 |

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 213794-M-53-Lapeer County | Bay | $1,406,021 | 0.56 | 24 |
| 221471-M-33-Ogemaw County | North | $7,480,000 | 0.48 | 25 |
| 212692-M-29-St. Clair County | Bay | $2,347,883 | 0.44 | 26 |
| 221469-US-31-Emmet County | North | $10,780,000 | 0.42 | 27 |
| 204883-I-94-Van Buren County | Southwest | $69,143,955 | 0.39 | 28 |
| 213446-US-2-Gogebic County | Superior | $19,236,430 | 0.37 | 29 |
| 215469-M-35-Marquette County | Superior | $2,542,430 | 0.34 | 30 |
| 208697-M-29-St. Clair County | Bay | $25,356,200 | 0.31 | 31 |
| 211047-M-134-Mackinac County | Superior | $919,953 | 0.30 | 32 |
| 208282-US-223-Lenawee County | University | $20,013,443 | 0.27 | 33 |
| 217409-M-95-Marquette County | Superior | $1,611,928 | 0.24 | 34 |
| 221111-US-127 N-Clinton County | University | $52,899,638 | 0.16 | 35 |
| 211155-US-23 N-Washtenaw County | University | $251,024,770 | 0.16 | 36 |
| 211147-M-99-Jackson County | University | $7,754,045 | 0.14 | 37 |
| 212694-M-46-Sanilac County | Bay | $14,835,913 | 0.11 | 38 |
| 110678-M-29-St. Clair County | Bay | $9,908,029 | 0.07 | 39 |

* Costs are current as of March 2025.

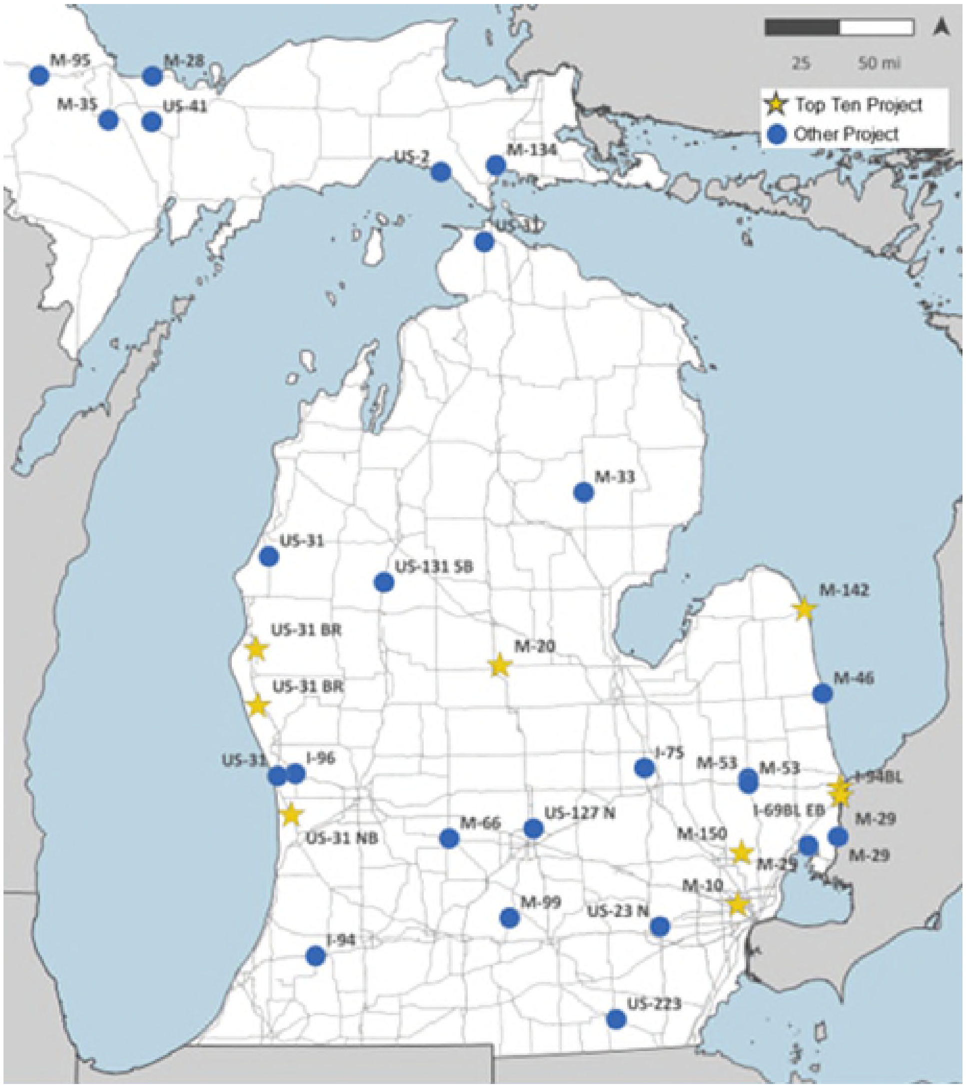


**Figure 4-1. Prototype Model Test Projects**

## Goal Area Scores & Ranks

The top projects in each goal area generated by the prototype model are listed in Tables 4-3 - 4-6. These goal-level ranks are based on projects' goal-specific SCR: a project's points for each measure in the goal area are summed and then divided by the project's cost.

**Table 4-3. Top Projects for Goal 1. Improve Asset Condition**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 211421-M-142-Huron County | Bay | $1,823,201 | 1.50 | 1 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 1.33 | 2 |

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 1.22 | 3 |
| 120048-M-85-Wayne County | Metro | $11,965,000 | 0.82 | 4 |
| 207968-US-31 BR-Oceana County | Grand | $8,475,000 | 0.76 | 5 |

* Costs are current as of March 2025.

**Table 4-4. Top Projects for Goal 2. Improve Safety**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 1.22 | 1 |
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 0.25 | 2 |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 0.21 | 3 |
| 213791-I-75-Genesee County | Bay | $39,305,339 | 0.29 | 4 |
| 201143-US-131 SB-Osceola County | Grand | $6,813,000 | 0.39 | 5 |

* Costs are current as of March 2025.

**Table 4-5. Top Projects for Goal 3. Enhance Accessibility & Mobility**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 2.76 | 1 |
| 210168-M-20-Isabella County | Bay | $3,779,560 | 1.56 | 2 |
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 1.10 | 3 |
| 209212-M-29-St. Clair County | Bay | $5,981,018 | 0.88 | 4 |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 0.57 | 5 |

* Costs are current as of March 2025.

**Table 4-6. Top Projects for Goal 4. Minimize Adverse Environmental Impacts**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---:|---|---|
| 214169-US-31 BR-Muskegon County | Grand | $2,062,000 | 1.18 | 1 |
| 209082-US-127-Clare County | Bay | $17,591,949 | 0.71 | 2 |
| 200682-US-31-Mason County | Grand | $6,810,000 | 0.67 | 3 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 0.64 | 4 |
| 213157-US-31 NB-Ottawa County | Grand | $3,600,000 | 0.63 | 5 |

* Costs are current as of March 2025.

# 5. Discussion

This section discusses the initial prototype model results. It provides a comparison between the top-ranking projects and the rest of the project cohort, as well as a discussion of -project points by goal area, variation in project ranks, and correlation among measures. It closes with a review of the limitations encountered during implementation of the prototype model.

## 5.1 Top-Ranking Projects

Comparing the top 10 projects to the remainder of the test projects across several key characteristics can reveal the extent to which top-ranking projects are representative of the test project cohort as a whole. It can also reveal project characteristics that correlate with high ranks, whether as a feature or unintended effect of the scoring system. A summary of the characteristics of the top 10 projects compared to all other projects is listed in Table 5-1.

**Table 5-1. Characteristics of Top-Ranking Projects and Other Projects**

| Observation | Top 10 | Other |
|---|---:|---:|
| Average cost | $6,522,323 | $22,605,755 |
| Average length (miles) | 2.71 | 4.16 |
| Percent urban | 80% | 34% |
| Percent rural | 20% | 66% |
| Percent with safety improvements | 50% | 45% |
| Percent with bike/pedestrian improvements | 50% | 7% |
| Percent with operational improvements | 30% | 14% |
| Percent with environmental improvements | 40% | 31% |
| Highest SCR | 4.67 | 0.96 |
| Lowest SCR | 1.08 | 0.07 |

### Geography

Projects that rank in the top 10 are distributed across several counties and MDOT regions. They are located in three MDOT Regions: Bay (five projects), Grand (three) and Metro (two). They include projects from eight different counties, with St. Clair County as the only county with more than one top 10 project: St Clair County (three projects), Huron County, Isabella County, Muskegon County, Oakland County, Oceana County, Ottawa County, and Wayne County. For reference, 26 counties in total are represented within the full test project cohort.

### Urban/Rural

Projects that rank in the top 10 are more likely to be located in urban contexts. Of the top 10 projects, 80% have a majority of the included routes classified as urban, compared to 34% of other projects.

### Project Cost

Projects that rank in the top 10 are on average less expensive than projects that do not. Top 10 projects have an average cost of $6,249,951, while other projects have an average cost of $22,605,755.

### Project Length

Projects that rank in the top 10 are on average shorter than projects that do not. Top 10 projects have an average length of 2.71 miles, while other projects have an average length of 4.16 miles.

### Additional Improvements

Projects that rank in the top 10 include safety, bike/pedestrian, operational, and environmental improvements at higher rates than projects that do not rank in the top 10. Of the top 10 projects, 50% include safety improvements (vs. 45% for other projects), 50% include bike/pedestrian improvements (vs. 7%), 30% include operational improvements (vs. 14%), and 40% include environmental improvements (vs. 31%). Figure 6 illustrates how top-ranking projects receive points across a range of goal areas.

| Implementation Consideration |
| --- |
| In future research or implementation efforts, MDOT may consider incorporating additional facility traits into project evaluation. Such additions may capture, in part, the variation in the degree of inclusion of additional improvements by facility type and could be incorporated, in particular, into the calculation of Goal 1 Improve Asset Condition measures. Further detail regarding potential measure calculation factors is provided in Section 3. |

At a high level, the comparison between top-ranking projects and all other projects underscores that projects tend to rank well if they address multiple objectives. In particular, lower cost projects that address multiple objectives tend to be more highly ranked. Generally, this reflects the scoring approach’s intended function: to support MDOT in identifying projects that produce the greatest benefit per dollar spent, with additional safety, bike/pedestrian, operational, or environmental improvements providing a mechanism for distinguishing between two otherwise similar pavement projects. It is difficult to draw further conclusions from the top-ranking projects given that weights on goals and measures are preliminary and likely to change.

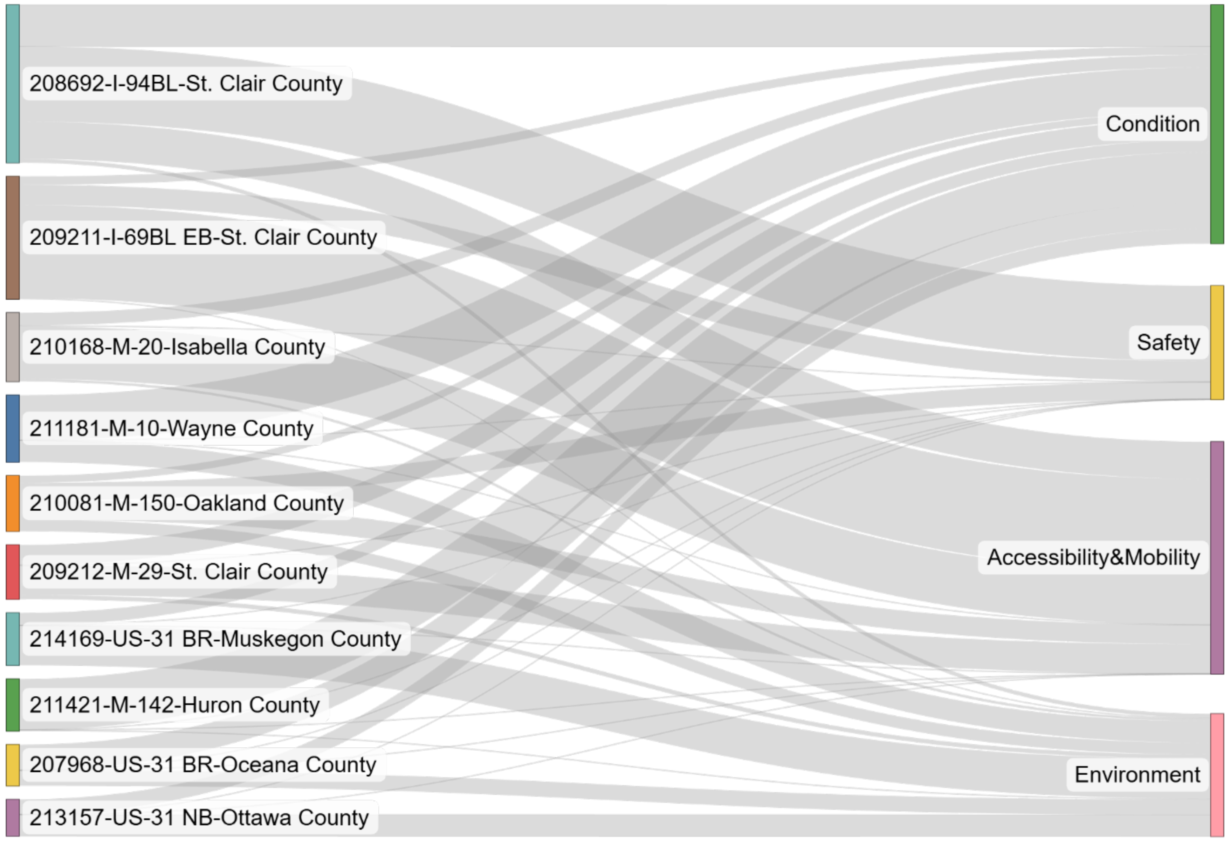


**Figure 5-1. Project Points by Goal Area for Top-Ranking Projects**

## 5.2 Goal & Measure Scores

### Distribution of Points

Within the prototype model, all projects receive points for multiple measures, though none receive points for all. The average number of measures for which a project receives points is four, or 40% of all measures. The number of projects that receive points, or a non-zero score, varies by measure. At a high level, most or all projects receive points for the first two condition measures, Measures 1.1 Change in RSL and 1.2 Increase in Federal Percent Good, which are closely tied to the impact of pavement activities. Fewer projects, however, receive points for measures tied to the impacts of supplementary safety, bike/pedestrian, operational, or environmental activities, which are not included in the scope of all R&R projects. Examples include Measures 2.2 Anticipated Crash Reduction (Intersection Improvement), 2.3 Anticipated Crash Reduction (VRU Safety Improvement), and 3.1 Increase in Bike & Pedestrian Accessibility.

The number of projects that receive scores of zero for each measure is provided in Table 5-2. It is important to note that it is not expected that all of the 39 test projects receive a non-zero score. There likely exist projects – or project details – that were not evaluated during the prototype implementation phase that would result in anticipated benefits for measures where the majority of test projects received scores of zeros. Additionally, a measure does not need to result in a non-zero score for every potential project in order for it to be considered effective. Measures where only a subset of projects receive anticipated benefits may serve to differentiate between otherwise similar projects.

**Table 5-2. Projects with Scores of Zero by Measure**

| Measure | Projects with Scores of Zero |
|---|---:|
| 1.1 Change in remaining service life (RSL) | 0 |
| 1.2 Increase in federal percent good | 2 |
| 1.3 Reduction in federal percent poor | 32 |
| 2.1 Anticipated crash reduction (lane departure) | 27 |
| 2.2 Anticipated crash reduction (intersection improvement) | 38 |
| 2.3 Anticipated crash reduction (vulnerable road user (VRU) safety improvement) | 34 |
| 3.1 Increase in bike & pedestrian accessibility | 32 |
| 3.2 Travel time savings | 32 |
| 4.1 Fuel savings | 10 |
| 4.2 Support for environmental commitments | 26 |

## Variation in Project Ranks

The results reflect a mix of projects at the top of the rankings for different aspects of the MODA model: 14 projects rank within the top three for at least one measure. However, select projects consistently rank in the top three across several measures. Both 211155-US-23 N-Washtenaw County (overall project rank: 36) and 210081-M-150-Oakland County (overall rank: five) rank in the top three projects for five measures.

## Measure Correlation

The correlation coefficients for each measure pairing, as well as between individual measures and project scores, SCR, and cost are presented in Table 5-3. A correlation coefficient of 1 indicates the two variables are highly positively correlated. A value of -1 indicates they are highly negatively correlated, while a value of 0 indicates they are uncorrelated. Review of the correlation coefficients yields the following insights:

- In all cases but one, the measures are not highly correlated with each other (defined as a correlation coefficient less than -0.90 or greater than 0.90). This is a positive outcome, as where two measures are highly correlated there may be reason to remove one from the analysis.

- Measures 1.1 and 1.2 are highly correlated with each other. This suggests that it may be possible to remove one of the measures from the analysis with significant impact on the results.
- Measure 4.1 shows somewhat high correlation with Measures 1.1, 1.2, and 3.2. For Measures 1.1 and 1.2, this a result of the fact that projects that reduce IRI (which is correlated with these measures) result in fuel consumption, which is captured in Measure 4.2. For Measure 3.2, the correlation appears to result from the fact that the small number of projects with non-zero values for Measure 3.2 tend to be higher cost projects with multiple types of improvements.
- Cost and Measure 3.2 are highly correlated for the same reason as that cited above.
- Neither Score or Cost are highly correlated with SCR. This is a positive outcome, as it suggests that the resulting priorities incorporate both Score and Cost and cannot be explained by one or the other in isolation.

**Table 5-3. Measure Correlation Coefficients**

| | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 4.1 | 4.2 | Score | SCR | Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.1** | 1.00 | 0.90 | -0.08 | 0.39 | 0.13 | -0.04 | -0.13 | 0.46 | 0.71 | 0.11 | 0.72 | -0.06 | 0.58 |
| | **1.2** | 1.00 | -0.06 | 0.38 | 0.09 | 0.02 | -0.06 | 0.35 | 0.73 | -0.01 | 0.69 | 0.09 | 0.45 |
| | | **1.3** | 1.00 | -0.10 | 0.51 | -0.09 | -0.10 | 0.11 | -0.03 | -0.08 | 0.17 | -0.01 | 0.05 |
| | | | **2.1** | 1.00 | -0.05 | 0.10 | 0.02 | 0.13 | 0.26 | -0.04 | 0.39 | -0.09 | 0.24 |
| | | | | **2.2** | 1.00 | -0.04 | -0.05 | 0.32 | 0.06 | -0.08 | 0.32 | -0.09 | 0.20 |
| | | | | | **2.3** | 1.00 | 0.68 | 0.07 | 0.10 | 0.05 | 0.41 | 0.60 | -0.05 |
| | | | | | | **3.1** | 1.00 | 0.04 | 0.02 | -0.05 | 0.34 | 0.65 | -0.08 |
| | | | | | | | **3.2** | 1.00 | 0.78 | -0.09 | 0.69 | -0.12 | 0.95 |
| | | | | | | | | **4.1** | 1.00 | -0.14 | 0.76 | -0.01 | 0.82 |
| | | | | | | | | | **4.2** | 1.00 | 0.20 | -0.01 | -0.04 |
| | | | | | | | | | | **Score** | 1.00 | 0.23 | 0.67 |
| | | | | | | | | | | | **SCR** | 1.00 | -0.21 |
| | | | | | | | | | | | | **Cost** | 1.00 |

*Measure names for reference:* ***1.1:*** *Change in remaining service life (RSL),* ***1.2:*** *Increase in federal percent good,* ***1.3:*** *Reduction in federal percent poor,* ***2.1****: Anticipated crash reduction (lane departure),* ***2.2:*** *Anticipated crash reduction (intersection improvement),* ***2.3:*** *Anticipated crash reduction (VRU safety improvement),* ***3.1****: Increase in bike & pedestrian accessibility,* ***3.2:*** *Travel time savings,* ***4.1:*** *Fuel savings, and* ***4.2:*** *Support for environmental commitments.*

## 5.3 Limitations & Alternative Approaches

### Data Availability

For the purposes of the prototype model, the research team used select test project data from MDOT paired with key assumptions to address data gaps (see Section 4.1 above). These assumptions enabled the project team to test the scoring approach; the project- and level-measure results illustrate how the proposed model would function and respond to a range of project characteristics. To use the scoring approach for decision-making purposes, full and accurate project data inputs would be required for each candidate project. Project data items required for scoring are listed in Table 5-4.

**Table 5-4. Project Data Required for Scoring**

| Item | Responsible Entity |
|---|---|
| Predominant fix type | Project engineer |
| Project limits | Project engineer |
| Implementation likelihood<br>Lane departure improvement<br>Intersection improvement<br>Vulnerable road user (VRU) safety improvement<br>Bike facility<br>Pedestrian facility<br>Congestion reduction<br>Activity that supports MDOT's environmental commitments | Project engineer |
| Extent of activity that supports MDOT's environmental commitments | Project engineer |
| Lanes | MDOT |
| VMT | MDOT |
| IRI | MDOT |
| Existing percent good | MDOT |
| Existing percent poor | MDOT |
| 5-year crash data by severity & type | MDOT |
| Project cost | Project engineer |
| Route criticality | MDOT |
| Functional classification | MDOT |
| Urban/rural classification | MDOT |

* Specific MDOT data systems and sources may be identified as part of initial implementation efforts, including through collaboration with the agency's Data Inventory and Integration Division.

## References

1. Michigan Department of Transportation (MDOT). *US-23 improvement project study - Ann Arbor.* N.d. https://www.michigan.gov/mdot/about/faqs/studies/us-23-study-ann-arbor.
2. U.S. Fish & Wildlife Service (FWS). *National Wetlands Inventory.* N.d. https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/.

# 6. Conclusions

This section includes a discussion of the further implementation of MODA at MDOT. It provides an overview of the potential to extend the prototype model beyond the current project's scope and to leverage existing tools and processes at MDOT.

## 6.1 Prototype Model Viability

Implementation of the prototype model demonstrates that a MODA-based approach can be used to assess and prioritize pavement rehabilitation and reconstruction projects at MDOT. Drawing on project scope and location data, the prototype model was used to evaluate a set of test projects against measures aligned with MDOT's asset condition, safety, accessibility and mobility, and environmental goals. The prototype model enabled MDOT to quantify projects' anticipated impacts and place them in the context of project costs, ultimately determining the expected benefits per dollar spent for each project. Based on this ratio, the prototype model was used to generate a list of ranked projects, with those anticipated to provide the greatest benefit per dollar spent ranked the highest.

## 6.2 Other MODA Applications

The MODA prototype model is designed to evolve with MDOT's changing emphasis areas and can be adapted to additional program categories. Any program with defined goals and measurable outcomes (or for which measurable outcomes can be devised) can be adapted to the model. Some potential program categories to consider are outlined below in Table 6-1.

Generally, if the data exist and are already being collected (such as on applications), the program area was assumed to have a "low" cost and effort to implement. Where program goals/objectives are set and data are collected but might have to be interpreted or analyzed, "Medium" costs were assumed. A "high" cost was assigned where all measures would have to be identified and quantified.

Program areas for which MODA is utilized may require commensurate changes in the CFP instructions.

**Table 6-1. Potential Multi-Objective Decision Analysis (MODA) Model Adaptations**

| Program | Adaptation of Goals & Measures | Data Availability | Level of Effort/Cost |
|---|---|---|---|
| Bridge Program | Goals and measures can be adapted in the model to account for other factors, such as whether the project corrects a condition of functional obsolescence or structural deficiency and the number of years the repair would add to the bridge's life. Other measures | Most of this data is readily available as part of the project submission process. Mobility, environmental, and safety values would be developed similar to the MODA for rehab/rehabilitation projects. | Medium |

| Program | Adaptation of Goals & Measures | Data Availability | Level of Effort/Cost |
|---|---|---|---|
| | could include increasing mobility, and safety and environmental enhancements. | | |
| Operations | MDOT's operational goal is to reduce delays and crashes and enhance reliability across the state transportation network. These objectives can be supported by measures aligned with federal system performance requirements. | This program is heavily data-driven and data points could be extracted from existing measures and analysis. | Low |
| Local Safety Program | Criteria from the MDOT 2027 Local Safety Call for Projects (e.g., high-risk rural road crash history and appropriate countermeasures) can be weighted for use in the model. Other criteria could include the number of financial goals the project contributes to (as defined in Exhibit 2 of the MDOT 2027 Local Safety Call for Projects) and whether social, environmental and economic impacts have been mitigated prior or the percent of preliminary engineering completed prior to application. | Most of the data is included in the submission. Some effort would be required to identify projects that contribute toward multiple financial goals. | Low |
| Local Agency Bridge Program | Selection formulas, including discretionary points based on Structure Inventory and Appraisal (SI&A) data, can be quantified and weighted in the model to support prioritization. | It appears that most of this data is included in the application process, but weighting will require internal agreement on priorities. | Medium |
| Transportation Systems Management and Operations (TSMO) | Measures and weights can be developed to align with the goals and strategic direction identified in the Strategic Plan for Intelligent Transportation Systems and the MDOT Call for Projects Manual. | Although the goals and strategies are well defined, performance measures have not been identified. Deciding which to include in the model, establishing quantifiable outcomes, and agreeing on how to measure and weigh them will require internal consensus. The number of | High |

| Program | Adaptation of Goals & Measures | Data Availability | Level of Effort/Cost |
|---|---|---|---|
| | | functional areas and their interdependencies add complexity to this process. | |
| Traffic Signal Modernization | Project selection criteria are established in the MDOT Call for Projects Manual. These can be quantified and/or weighted and pulled into the model. | Quantifying desired outcomes and weights will require internal agreement. | Medium |
| Carpool Parking Lot Program | Measures can be devised for the selection criteria outlined in the MDOT Call for Projects Manual. Those measures can be weighted or changed based on yearly priorities, such as weighting for public/private partnerships and providing intermodal connections. | Quantifying desired outcomes and weights will require internal agreement. | Medium to High |
| State Planning and Research – Passenger Transportation (Sec. 5304) | Projects must demonstrate statewide benefits and undergo a competitive selection process. These benefits can be explicitly defined, measured, and weighted using MODA. | Existing selection criteria were not found. Defining statewide benefits and quantifying desired outcomes and weights will require internal agreement. | High |

| Implementation Consideration |
|---|
| MDOT staff have identified additional potential opportunities for MODA application, including MDOT's Ancillary Structures (AS) and highway-railroad grade crossing programs. For these programs, recent or routine inspection activities and existing program guidance, such as the Michigan Ancillary Structures Inspection Manual (MiASIM), may serve as foundations for the development of MODA goals and measures, as well as the implementation of a scoring process. The potential value and feasibility of applying MODA in these contexts should be vetted by program staff. |

## 6.3 Tools & Processes

MDOT is actively developing the Project Identification Tool (PIT) to support cost-benefit analyses that assess the utility and viability of potential pavement projects. Once completed, PIT will allow MDOT to compare its process elements and outputs with those of the MODA framework, including the measures used to quantify the "Improve Asset Condition" goal.

Ultimately, the PIT could be integrated into a multi-objective data analysis tool by utilizing its pavement optimization outputs in place of some or all of the model's "improve asset condition" measures. The MODA tool would then evaluate outcomes across all four focus areas: pavement condition, safety, mobility, and environmental. The final forms of both PIT and MDOT will require refinement and optimization.

MDOT might also consider pursuing the acquisition and application of a commercial decision support tool to support the application of the MODA process moving forward or, alternatively, building a tool in-house to perform the same function. A decision support tool would be most valuable in facilitating iterative rounds of MODA process implementation and improvement; it would not address challenges related to data availability and access.

To evaluate the potential utility of this type of tool, MDOT should conduct further conversations with other state departments of transportation. They should ask peer transportation agencies about their use of decision support tools, including the type of tools used, what the agency found value, and tool limitations.

# Appendix A. Sample Calculations

## Measure Calculations

### Measure 1.1: Change in Remaining Service Life (RSL)

A sample calculation for Measure 1.1 is provided below, with the following project used as an example: 211181-M-10-Wayne County.

**Table A-1. Measure 1.1 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Predominant fix type | Concrete pavement restoration |
| Lane miles | 69.297 |
| **Constants/Parameters** | |
| Estimated fix life (years) | 11.5 |
| Route criticality factor value | 1 |
| Functional classification factor value | 1 |
| Geographic context factor value | 1 |

The calculation of the benefit associated with change in RSL is represented by Equation 9.

$$Benefit = 69.297 * 11.5 * 1 * 1 * 1 = 797 \quad (9)$$

### Measure 1.2: Increase in Federal Percent Good

A sample calculation for Measure 1.2 is provided below, with the following project used as an example: 213791-I-75-Genesee County.

**Table A-2. Measure 1.2 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Predominant fix type | Mill Existing & Multiple Course HMA Overlay |
| Lane miles | 42.352 |

| Description | Value/Details |
|---|---|
| Existing percent good | 0.6% |
| Resulting percent good | 100.0% |
| **Constants/Parameters** | |
| Route criticality factor value | 1 |
| Functional classification factor value | 1 |
| Geographic context factor value | 1 |

The calculation of the benefit associated with the increase in federal percent good is represented by Equation 10.

$$Benefit = 42.352 * (1 - 0.006) * 1 \ * 1 * 1 = 42.1 \quad (10)$$

## Measure 1.3: Reduction in Federal Percent Poor

A sample calculation for Measure 1.3 is provided below, with the following project used as an example: 211421-M-142-Huron County.

**Table A-3. Measure 1.3 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Predominant fix type | Mill Existing & Multiple Course HMA Overlay |
| Lane miles | 1.52 |
| Existing percent poor | 100.0% |
| Resulting percent poor | 0.0% |
| **Constants/Parameters** | |
| Route criticality factor value | 1 |
| Functional classification factor value | 1 |
| Geographic context factor value | 1 |

The calculation of the benefit associated with the reduction in federal percent poor is represented by Equation 11.

$$Benefit = 1.52 * (1 - 0) * 1 \ * 1 * 1 = 1.52 \quad (11)$$

## Measure 2.1: Anticipated Crash Reduction (Lane Departure)

A sample calculation for Measure 2.1 is provided below, with the following project used as an example: 201143-US-131 SB-Osceola County.

**Table A-4. Measure 2.1 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Implementation likelihood | |
| Project limits | 0.67 miles north of US-10 north to 0.81 miles south of 14 Mile Road; Luther/Leroy Carpool Parking Lot Exit 162 Facility ID 367004; Ashton Carpool Parking Lot Exit 159 Facility ID 367005 |
| Number of crashes at project location in most recent five years by crash type and severity | *Fatal crashes*<br>1 overturn<br>*Injury crashes*<br>2 overturn, 2 misc. multiple vehicles<br>*Property damage only crashes*<br>5 overturn, 5 fixed object, 4 misc. single vehicle, 3 other object, 2 sideswipe same, 1 misc. multiple vehicles, 1 rear end straight |
| **Constants/Parameters** | |
| *Implementation likelihood* | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |
| *Value by crash severity* | |
| Fatalities/fatal crashes | $12,500,000 |
| Serious injuries/serious injury crashes | $287,780 |
| Other crashes | $9,100 |
| *Crash Reduction Factor (CRF)* | |

| Description | Value/Details |
|---|---|
| CRF value | 0.07 |
| Applicable crash types | Fixed object, sideswipe, head-on, overturn |

The calculation of the benefit associated with the anticipated crash reduction (lane departure) is represented by Equation 12.

$$Benefit = 1 * .07 * (1 * 12{,}500{,}000 + 2 * 287{,}780 + 12 * 9{,}100) = 922{,}933 \quad (12)$$

## Measure 2.2: Anticipated Crash Reduction (Intersection)

A sample calculation for Measure 2.2 is provided below, with the following project used as an example: 204883-I-94-Van Buren County.

**Table A-5. Measure 2.2 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Implementation likelihood | Yes |
| Project limits | East of M-51 to east of M-40 |
| Number of crashes at project location in most recent five years by crash type and severity | 1 fatal crash (0 intersection-related)<br>77 injury crashes (16 intersection-related)<br>389 property damage crashes (87 intersection-related) |
| **Constants/Parameters** | |
| *Implementation likelihood* | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |
| *Value by crash severity* | |
| Fatalities/fatal crashes | $12,500,000 |
| Serious injuries/serious injury crashes | $287,780 |
| Other crashes | $9,100 |

| Description | Value/Details |
|---|---|
| *Crash Reduction Factor (CRF)* | |
| CRF value | 0.27 |
| Applicable crash types | All intersection-related crashes |

The calculation of the benefit associated with the anticipated crash reduction (intersection) is represented by Equation 13.

$$Benefit = 1 * .27 * (0 * 12{,}500{,}000 + 16 * 287{,}780 + 87 * 9{,}100) = \mathbf{1{,}456{,}969} \quad (13)$$

## Measure 2.3: Anticipated Crash Reduction (Vulnerable Road User (VRU) Safety Improvement)

A sample calculation for Measure 2.3 is provided below, with the following project used as an example: 210081-M-150-Oakland County.

**Table A-6. Measure 2.3 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Implementation likelihood | Yes |
| Project limits | M-59 to Avon Road |
| Number of crashes at project location in most recent five years by crash type and severity | 1 fatal crash (0 bike/pedestrian-related)<br>283 injury crashes (3 bike/pedestrian-related)<br>1,175 property damage crashes (1 bike/pedestrian-related) |
| **Constants/Parameters** | |
| *Implementation likelihood* | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |
| *Value by crash severity* | |
| Fatalities/fatal crashes | $12,500,000 |

| Description | Value/Details |
|---|---|
| Serious injuries/serious injury crashes | $287,780 |
| Other crashes | $9,100 |
| *Crash Reduction Factor (CRF)* | |
| CRF value | 0.63 |
| Applicable crash types | All bike/pedestrian-related crashes |

The calculation of the benefit associated with the anticipated crash reduction (VRU) is represented by Equation 14.

$$Benefit = 1 * .63 * (0 * 12{,}500{,}000 + 3 * 287{,}780 + * 9{,}100) = \mathbf{549{,}637} \quad (14)$$

## Measure 3.1: Increase in Bike & Pedestrian Accessibility

A sample calculation for Measure 3.1 is provided below, with the following project used as an example: 210168-M-20-Isabella County.

**Table A-7. Measure 3.1 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Project limits | West of M-20/US-127 intersection to Turtle Trail; CPL facility ID 537001 |
| *Implementation likelihood* | |
| Pedestrian facility | Yes |
| Bike facility | No |
| **Constants/Parameters** | |
| *Implementation likelihood* | |
| Yes; project has been identified in a plan or as a matter of policy. | 1.00 |
| Maybe; improvement is under consideration but is not identified in a plan or as a matter of policy. | 0.50 |

| Description | Value/Details |
|---|---|
| No; improvement is not likely. | 0.00 |
| *Primary geography traits* | |
| Population density | 2,748.27 |
| Cyclist commute share | 1.90% |
| *Calculation Parameters* | |
| Buffer 1 (miles) | 0.25 |
| Buffer 2 (miles) | 0.50 |
| Buffer 3 (miles) | 1.00 |
| Existing bike rate intercept | 0.3% |
| Existing bike rate slope | 0.96 |
| New bicyclist demand multiplier, Buffer 1 | 1.93 |
| New bicyclist demand multiplier, Buffer 2 | 1.11 |
| New bicyclist demand multiplier, Buffer 3 | 0.39 |
| New pedestrian minimum | 0.18% |
| New pedestrian maximum | 2.27% |
| New pedestrian slope | 0.00022% |
| New pedestrian intercept | 0.07% |
| **Derived Inputs** | B1 |
| Length (miles) | 1.11 |
| Population of Buffer 1 | 1,914 |
| Population of Buffer 2 | 2,993 |
| Population of Buffer 3 | 9,224 |

The calculation of the benefit associated with the increase in bike and pedestrian accessibility is represented by Equation 15.

$$Benfit = 0.00 * (0.03 + 0.96 * .171) * ( 1{,}914 * 1.93 + 2{,}993 * 1.11 + 9{,}224 * 0.39 ) + 1.00 * \text{MIN}(0.027, \text{MAX}(.0018, .0007 + .0000022 * 2{,}748.27)) * 1{,}914 = \mathbf{12.9} \quad (15)$$

## Measure 3.2: Travel Time Savings

A sample calculation for Measure 3.2 is provided below, with the following project used as an example: 211155-US-23 N-Washtenaw County.

**Table A-8. Measure 3.2 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Project limits | M-14 to I-94 |
| Project VMT | 523,772 |
| Congestion reduction likelihood | The project will reduce congestion and is part of an existing plan. |
| **Constants/Parameters** | |
| *Congestion reduction likelihood* | |
| The project will reduce congestion and is part of an existing plan. | 1.00 |
| The project may reduce congestion but is not included in an existing plan for congestion reduction. | 0.50 |
| The project is not expected to reduce congestion. | 0.00 |

The calculation of the benefit associated with travel time savings is represented by Equation 16.

$$Benefit = 1 * 523{,}772 = \mathbf{523{,}772} \quad (16)$$

## Measure 4.1: Fuel Savings

A sample calculation for Measure 4.1 is provided below, with the following project used as an example: 213791-I-75-Genesee County.

**Table A-9. Measure 4.1 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Project limits | Court St. to north junction I-475 |
| Existing pavement smoothness | 98 |
| Project location VMT | 454,237 |
| Congestion reduction likelihood | The project is not expected to reduce congestion. |
| **Constants/Parameters** | |
| *Congestion reduction likelihood* | |
| The project will reduce congestion and is part of an existing plan. | 1.00 |
| The project may reduce congestion but is not included in an existing plan for congestion reduction. | 0.50 |
| The project is not expected to reduce congestion. | 0.00 |
| **IRI2:** assumed IRI for smooth pavement | 76.0 |
| **R:** 63.4 (conversion of IRI to metric units) / 1.6% (reduction for each meter/kilometer change in IRI) | 3,962.5 |
| **FC:** typical reduction in fuel consumption for an R&R project with a congestion reduction improvement (hours/car) | 0.01 |

The calculation of the benefit associated with fuel savings is represented by Equation 17.

$$Benefit = (((98 - 76) / 3{,}962.5) + 0.0 * 0.01) * 454{,}237 = \mathbf{2{,}522} \quad (17)$$

## Measure 4.2: Fuel Savings

A sample calculation for Measure 4.2 is provided below, with the following project used as an example: 209082-US-127-Clare County.

**Table A-10. Measure 4.2 Sample Calculation Data Inputs**

| Description | Value/Details |
|---|---|
| **Variables** | |
| Implementation likelihood | Yes, it includes an activity that supports MDOT's environmental commitments. |
| Type of activity | Wetland activity |
| Extent of activity (acres) | 11 |
| **Constants/Parameters** | |
| *Implementation likelihood* | |
| Yes | 1.00 |
| Maybe | 0.50 |
| No | 0.00 |

The calculation of the benefit associated with support for environmental commitments is represented by Equation 18.

$$Benefit = (1 * 11) = \mathbf{11} \quad (18)$$

# Project Score Calculation

## Scaled Measure Scores

To facilitate comparisons across measure areas and the calculation of combined goal and project scores, individual measure scores are converted to a scale of 0 to 100, with the top-performing project for each measure receiving a score of 100 and other projects scored proportionately. Sample unscaled and scaled measure scores from the initial prototype model implementation are provided below for the following project: 210168-M-20-Isabella County. The example project receives a scaled score of 100 for Measure 3.1, meaning it is the top-ranking project for this measure. The project receives additional non-zero scaled scores for Measures 1.1, 1.2, 2.3, and 4.1, reflecting benefits scaled proportionately to the top-ranking project for these measures.

**Table A-11. Sample Scaled Measure Scores**

| Measure | Unscaled Score | Scaled Score |
|---|---|---|
| **Goal 1: Improve Asset Condition** | | |

| Measure | Unscaled Score | Scaled Score |
|---|---|---|
| 1.1: Change in RSL | 76.16 | 9.56 |
| 1.2: Increase in Federal Percent Good | 5.11 | 7.38 |
| 1.3: Reduction in Federal Percent Poor | 0 | 0 |
| **Goal 2: Improve Safety** | | |
| 2.1: Anticipated Crash Reduction (Lane Departure) | 0 | 0 |
| 2.2: Anticipated Crash Reduction (Intersection Improvement) | 0 | 0 |
| 2.3: Anticipated Crash Reduction (VRU Safety Improvement) | 5,733 | 1.04 |
| **Goal 3: Enhance Accessibility & Mobility** | | |
| 3.1: Increase in Bike & Pedestrian Accessibility | 353 | 100 |
| 3.2: Travel Time Savings | 0 | 0 |
| **Goal 4: Minimize Adverse Environmental Impacts** | | |
| 4.1 Fuel Savings | 253 | 2.21 |
| 4.2 Support for Environmental Commitments | 0 | 0 |

## Weighted Measure Scores

After measure scores are converted to a common scale, they are multiplied by a set of weights reflective of the relative importance of each measure. In the initial prototype model implementation, all four measure goal areas were assigned equal weights, with individual measures assigned equal weights within their respective goal areas. MDOT then conducted a workshop to establish goal and measure weights aligned with the agency's priorities (Appendix B). Unweighted and weighted scores are provided below for the same sample project, using the initial prototype equal weighting approach. The measure weights are provided for reference.

**Table A-12. Sample Weighted Measure Scores**

| Measure | Weight | Scaled Score | Weighted Score |
|---|---|---|---|
| **Goal 1: Improve Asset Condition** | | | |
| 1.1: Change in RSL | 33% | 9.56 | 3.15 |
| 1.2: Increase in Federal Percent Good | 33% | 7.38 | 2.44 |

| Measure | Weight | Scaled Score | Weighted Score |
|---|---|---|---|
| 1.3: Reduction in Federal Percent Poor | 33% | 0 | 0 |
| **Goal 2: Improve Safety** | | | |
| 2.1: Anticipated Crash Reduction (Lane Departure) | 33% | 0 | 0 |
| 2.2: Anticipated Crash Reduction (Intersection Improvement) | 33% | 0 | 0 |
| 2.3: Anticipated Crash Reduction (VRU Safety Improvement) | 33% | 1.04 | 0.34 |
| **Goal 3: Enhance Accessibility & Mobility** | | | |
| 3.1: Increase in Bike & Pedestrian Accessibility | 50% | 100 | 50 |
| 3.2: Travel Time Savings | 50% | 0 | 0 |
| **Goal 4: Minimize Adverse Environmental Impacts** | | | |
| 4.1 Fuel Savings | 50% | 2.21 | 1.11 |
| 4.2 Support for Environmental Commitments | 50% | 0 | 0 |

## Goal Area Scores

Next, scores are aggregated at the goal level. For each goal area, the associated individual measure scores are summed. Goal area scores are provided below for the sample project, with scaled and weighted individual measure scores are provided for reference.

**Table A-13. Sample Goal Area Scores**

| Goal | Score |
|---|---|
| **Goal 1: Improve Asset Condition** | **5.59** |
| 1.1: Change in RSL | 3.15 |
| 1.2: Increase in Federal Percent Good | 2.44 |
| 1.3: Reduction in Federal Percent Poor | 0 |
| **Goal 2: Improve Safety** | **0.34** |
| 2.1: Anticipated Crash Reduction (Lane Departure) | 0 |
| 2.2: Anticipated Crash Reduction (Intersection Improvement) | 0 |
| 2.3: Anticipated Crash Reduction (VRU Safety Improvement) | 0.34 |

| Goal | Score |
|---|---|
| **Goal 3: Enhance Accessibility & Mobility** | **50** |
| 3.1: Increase in Bike & Pedestrian Accessibility | 50 |
| 3.2: Travel Time Savings | 0 |
| **Goal 4: Minimize Adverse Environmental Impacts** | **1.11** |
| 4.1 Fuel Savings | 1.11 |
| 4.2 Support for Environmental Commitments | 0 |

## Weighted Goal Area Scores

Goal area scores are multiplied by a set of weights reflective of the relative importance of each goal area. In the initial prototype model implementation, all four measure goal areas were assigned equal weights. MDOT then conducted a workshop to establish weights aligned with the agency's priorities (Appendix B). Unweighted and weighted scores are provided below for the sample project, using the initial prototype equal weighting approach. The goal area weights are provided for reference.

**Table A-14. Sample Weighted Goal Area Scores**

| Goal | Weight | Score | Weighted Score |
|---|---|---|---|
| Goal 1: Improve Asset Condition | 25% | 5.59 | 1.40 |
| Goal 2: Improve Safety | 25% | 0.34 | 0.09 |
| Goal 3: Enhance Accessibility & Mobility | 25% | 50 | 12.5 |
| Goal 4: Minimize Adverse Environmental Impacts | 25% | 1.11 | 0.28 |

## Total Project Score

Weighted goal area scores are summed to provide a total score, reflective of the project's combined anticipated benefit. This step is illustrated below for the sample project, with weighted goal area scores included for reference.

**Table A-15. Sample Total Project Score**

| Project | Total Project Score |
|---|---|
| **210168-M-20-Isabella County** | **14.27** |
| Goal 1: Improve Asset Condition | 1.40 |

| Project | Total Project Score |
|---|---|
| Goal 2: Improve Safety | 0.09 |
| Goal 3: Enhance Accessibility & Mobility | 12.5 |
| Goal 4: Minimize Adverse Environmental Impacts | 0.28 |

## Score-Cost Ratio (SCR) & Rank

Total project scores are divided by project costs to calculate a Score-Cost Ratio (SCR), representing cost effectiveness. Note that, for ease of review, initial SCRs are multiplied by 1,000. This value, the SCR, is the value on which projects are ranked: the project with the highest SCR, or greatest cost effectiveness, is ranked first, with all other projects ranked in descending order. An example of these products are provided below for the same project. The example project's total project score and cost are provided for reference. This project receives an overall rank of one, meaning it has the greatest SCR out of all projects in the test cohort.

**Table A-16. Sample Total Project Score & Score-Cost Ratio**

| Project | Total Project Score | Project Cost | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 210168-M-20-Isabella County | 14.27 | $3.8M | 3.78 | 1 |

# Appendix B. Weighting Workshop

## Purpose

MDOT staff established relative weights for the goals and measures of the proposed MODA model via an interactive workshop. The workshop was conducted after initial implementation of the prototype model to support future implementation efforts at MDOT. It is aligned with step six of the process for MODA implementation (Figure 2).

## Structure

The workshop was held virtually on Thursday, November 13 at 1:00-3:00 pm. A total of 40 MDOT staff were invited to participate. In advance of the workshop, attendees were provided with materials that described the workshop purpose and structure, provided context for MODA and the research project, and outlined the proposed MODA approach, including sample project score calculations.

The workshop included a review of the proposed goals and measures of effectiveness and two interactive exercises through which MDOT staff provided their input on the relative weights of the MODA prototype elements: an Analytical Hierarchy Process (AHP) exercise and a Delphi approach exercise.

## Analytical Hierarchy Process (AHP) Exercise

In the AHP exercise, MDOT staff participated in a poll with 14 pairwise comparisons to evaluate the relative importance of the four goals and the measures within a goal area. For each pairwise comparison, participants were asked to select a position on a scale extending from 'A is extremely more important than B' to 'B is extremely more important than A,' with a value assigned to each position on the scale. A set of weights was derived from their responses.

## Delphi Exercise

In the Delphi exercise, participants engaged in two rounds of voting in which they entered their preferred weights for each goal and measure into a spreadsheet tool. After each round, the group reviewed the average weights derived from all participants' responses, as well as maximum and minimum desired weights and individuals' reasoning.

## Results

The results of round two of the Delphi exercise are considered to be the weights established by MDOT via the weighting workshop. These were used in the revised MODA analysis and are provided below.

**Table B-1. Revised Weights from Weighting Workshop**

| Model Element | Weight |
|---|---|
| **Goals** | |
| Goal 1. Improve asset condition | 49.55% |

| Model Element | Weight |
|---|---|
| Goal 2. Improve safety | 25.76% |
| Goal 3. Enhance accessibility & mobility | 14.86% |
| Goal 4. Minimize adverse environmental impacts | 9.83% |
| **Measures** | |
| *Goal 1. Improve asset condition* | **100.0%** |
| Measure 1.1 Change in remaining service life (RSL) | 46.1% |
| Measure 1.2 Increase in federal percent good | 20.0% |
| Measure 1.3. Reduction in federal percent poor | 33.9% |
| *Goal 2. Improve safety* | **100.0%** |
| Measure 2.1 measure anticipated crash reduction (lane departure) | 36.3% |
| Measure 2.2 anticipated crash reduction (intersection improvement) | 34.0% |
| Measure 2.3 anticipated crash reduction (VRU safety improvement) | 29.7% |
| *Goal 3. Enhance accessibility & mobility* | **100.0%** |
| Measure 3.1 Increase in bike & pedestrian accessibility | 40.3% |
| Measure 3.2 Travel time savings | 59.7% |
| *Goal 4. Minimize adverse environmental impacts* | **100.0%** |
| Measure 4.1 Fuel savings | 55.0% |
| Measure 4.2 Support for environmental commitments | 45.0% |

# Appendix C. Revised Findings & Discussion

## Findings

### Project Scores & Rankings

The project priorities generated by the MODA model with the revised ranks established in the weighting workshop are listed by rank, from highest to lowest priority, in Table C-1. These ranks are based on projects' overall SCR. The change from in rank from the initial prototype model priorities is included for reference. It is important to note that, here, a 'negative' change in rank means the project moved up the list of priorities and is a 'better' position; for example, a change of -2 means the project moved up two spots, towards the top of the list. The original priorities are provided in Section 4. The revised weights are provided in Appendix B. Additional details about each candidate project are provided in Appendix D.

**Table C-1. Revised Model Priorities**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank | Change in Rank |
|---|---|---|---|---|---|
| ***Top 10 Projects*** | | | | | |
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 5.03 | 1 | 0 |
| 211421-M-142-Huron County | Bay | $1,823,201 | 3.05 | 2 | -6 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 2.90 | 3 | -1 |
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 2.38 | 4 | 2 |
| 207968-US-31 BR-Oceana County | Grand | $8,475,000 | 1.70 | 5 | -4 |
| 209212-M-29-St. Clair County | Bay | $5,981,018 | 1.69 | 6 | 0 |
| 120048-M-85-Wayne County | Metro | $11,965,000 | 1.67 | 7 | -6 |
| 210168-M-20-Isabella County | Bay | $3,779,560 | 1.57 | 8 | 5 |
| 208891-US-41-Alger County | Superior | $8,525,405 | 1.57 | 9 | -6 |
| 208803-US-45-Gogebic County | Superior | $7,091,000 | 1.46 | 10 | -6 |
| ***Other Projects*** | | | | | |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 1.35 | 11 | 6 |
| 201143-US-131 SB-Osceola County | Grand | $6,813,000 | 1.25 | 12 | -10 |
| 214169-US-31 BR-Muskegon County | Grand | $2,062,000 | 1.17 | 13 | 6 |

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank | Change in Rank |
|---|---|---|---|---|---|
| 213157-US-31 NB-Ottawa County | Grand | $3,600,000 | 1.14 | 14 | 4 |
| 211012-M-28-Alger County | Superior | $14,090,000 | 1.08 | 15 | 1 |
| 216348-US-31-Ottawa County | Grand | $6,665,000 | 1.03 | 16 | -1 |
| 213794-M-53-Lapeer County | Bay | $1,406,021 | 1.02 | 17 | -7 |
| 210819-M-66-Barry County | Grand | $1,258,000 | 0.94 | 18 | -3 |
| 217178-US-2-Mackinac County | Superior | $9,082,900 | 0.93 | 19 | -1 |
| 204355-M-53-Lapeer County | Bay | $5,922,666 | 0.90 | 20 | 2 |
| 211173-I-96-Muskegon County | Grand | $23,186,000 | 0.87 | 21 | 2 |
| 213791-I-75-Genesee County | Bay | $39,305,339 | 0.87 | 22 | -1 |
| 200682-US-31-Mason County | Grand | $6,810,000 | 0.85 | 23 | 11 |
| 212692-M-29-St. Clair County | Bay | $2,347,883 | 0.84 | 24 | -2 |
| 209082-US-127-Clare County | Bay | $17,591,949 | 0.76 | 25 | 14 |
| 213446-US-2-Gogebic County | Superior | $19,236,430 | 0.76 | 26 | -3 |
| 215469-M-35-Marquette County | Superior | $2,542,430 | 0.73 | 27 | -3 |
| 211047-M-134-Mackinac County | Superior | $919,953 | 0.60 | 28 | -4 |
| 221471-M-33-Ogemaw County | North | $7,480,000 | 0.59 | 29 | 4 |
| 204883-I-94-Van Buren County | Southwest | $69,143,955 | 0.55 | 30 | 2 |
| 217409-M-95-Marquette County | Superior | $1,611,928 | 0.50 | 31 | -3 |
| 221469-US-31-Emmet County | North | $10,780,000 | 0.49 | 32 | 5 |
| 208282-US-223-Lenawee County | University | $20,013,443 | 0.46 | 33 | 0 |
| 208697-M-29-St. Clair County | Bay | $25,356,200 | 0.32 | 34 | 3 |
| 212694-M-46-Sanilac County | Bay | $14,835,913 | 0.29 | 35 | -3 |
| 221111-US-127 N-Clinton County | University | $52,899,638 | 0.25 | 36 | 1 |
| 211147-M-99-Jackson County | University | $7,754,045 | 0.24 | 37 | 0 |
| 211155-US-23 N-Washtenaw County | University | $251,024,770 | 0.17 | 38 | 2 |
| 110678-M-29-St. Clair County | Bay | $9,908,029 | 0.13 | 39 | 0 |

* Costs are current as of March 2025.

## Goal Area Scores & Ranks

The top projects in each goal area generated by the MODA model with the revised ranks are listed in Tables C-2-C-5. These goal-level ranks are based on projects' goal-specific SCR: a project's points for each measure in the goal area are summed and then divided by the project's cost.

**Table C-2. Revised Top Projects for Goal 1. Improve Asset Condition**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 211421-M-142-Huron County | Bay | $1,823,201 | 3.04 | 1 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 2.62 | 2 |
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 2.41 | 3 |
| 120048-M-85-Wayne County | Metro | $11,965,000 | 1.66 | 4 |
| 208891-US-41-Alger County | Superior | $8,525,405 | 1.57 | 5 |

* Costs are current as of March 2025.

**Table C-3. Revised Top Projects for Goal 2. Improve Safety**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 2.04 | 1 |
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 0.55 | 2 |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 0.49 | 3 |
| 213791-I-75-Genesee County | Bay | $39,305,339 | 0.24 | 4 |
| 201143-US-131 SB-Osceola County | Grand | $6,813,000 | 0.21 | 5 |

* Costs are current as of March 2025.

**Table C-4. Revised Top Projects for Goal 3. Enhance Accessibility & Mobility**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 209211-I-69BL EB-St. Clair County | Bay | $4,602,156 | 1.33 | 1 |
| 210168-M-20-Isabella County | Bay | $3,779,560 | 0.75 | 2 |
| 208692-I-94BL-St. Clair County | Bay | $2,470,293 | 0.53 | 3 |

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 209212-M-29-St. Clair County | Bay | $5,981,018 | 0.46 | 4 |
| 210081-M-150-Oakland County | Metro | $19,930,000 | 0.30 | 5 |

* Costs are current as of March 2025.

**Table C-5. Revised Top Projects for Goal 4. Minimize Adverse Environmental Impacts**

| Project Description | Region | Cost* | Score-Cost Ratio (SCR) | Rank |
|---|---|---|---|---|
| 214169-US-31 BR-Muskegon County | Grand | $2,062,000 | 0.42 | 1 |
| 211181-M-10-Wayne County | Metro | $12,500,000 | 0.28 | 2 |
| 209082-US-127-Clare County | Bay | $17,591,949 | 0.25 | 3 |
| 200682-US-31-Mason County | Grand | $6,810,000 | 0.24 | 4 |
| 213157-US-31 NB-Ottawa County | Grand | $3,600,000 | 0.22 | 5 |

* Costs are current as of March 2025.

# Discussion

## Top-Ranking Projects

A summary of the characteristics of the revised top 10 projects compared to all other projects is listed in Table C-6.

**Table C-6. Revised Characteristics of Top-Ranking Projects and Other Projects**

| Observation | Top 10 | Other |
|---|---|---|
| Average cost | $6,721,263 | $22,537,155 |
| Average length (miles) | 4.11 | 3.68 |
| Percent urban | 60% | 41% |
| Percent rural | 40% | 59% |
| Percent with safety improvements | 50% | 45% |
| Percent with bike/pedestrian improvements | 40% | 10% |
| Percent with operational improvements | 20% | 17% |
| Percent with environmental improvements | 10% | 41% |
| Highest SCR | 5.03 | 1.35 |

| | | |
|---|---|---|
| Lowest SCR | 1.46 | 0.13 |

## Geography

Projects that rank in the top 10 are distributed across several counties and MDOT regions. They are located in four MDOT Regions: Bay (five projects), Metro (two), Superior (two), and Grand (one). They include projects from 10 different counties: St Clair County (three projects), Wayne County (two), Alger County (one), Gogebic County (1), Huron County (1), Isabella County (1), and Oceana County (1). For reference, 26 counties in total are represented within the full test project cohort.

## Urban/Rural

Projects that rank in the top 10 are more likely to be located in urban contexts. Of the top 10 projects, 60% have a majority of the included routes classified as urban, compared to 41% of other projects.

## Project Cost

Projects that rank in the top 10 are on average less expensive than projects that do not. Top 10 projects have an average cost of $6,721,263, while other projects have an average cost of $22,537,155.

## Project Length

Projects that rank in the top 10 are on average longer than projects that do not. Top 10 projects have an average length of 4.11 miles, while other projects have an average length of 3.68 miles.

## Additional Improvements

## Comparison to Initial Prototype Model Results

A comparison of the initial prototype model results, with the equal weighting schema, and the revised results, reflective of the weights established by MDOT, yields the following high-level insights:

- The revised results reflect slightly greater geographic diversity among top-ranking projects, with a greater number of regions and counties represented among the Top 10 projects.
- As anticipated given the weighting schema established by MDOT staff, the results reflect a strong correlation among top-scoring projects for Goal 1. Improve asset condition and overall top-ranking projects. All projects that rank within the top five for Goal 1 rank within the top 10 overall. Conversely, only one project that ranks in the top five projects for Goal 4. Mitigate adverse environmental impacts ranks within the top 10 overall.

# Appendix D. Scoring Tools

The attached spreadsheet tools can support MDOT in implementing the proposed MODA approach moving forward. Attachment D.1 provides a tool for conducting project evaluation with default equal weights, in alignment with the original implementation of the prototype model. Attachment D.2 provides a tool for conducting project evaluation with the weights established by MDOT via the weighting workshop. Aside from the weights, the scoring methodology is consistent across the two tools.