MnDOT Measures of Financial Effectiveness

2019
EVALUATION REPORT

Program Evaluation Division

OFFICE OF THE LEGISLATIVE AUDITOR
STATE OF MINNESOTA

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STATE OF MINNESOTA • James Nobles, Legislative Auditor

March 2019

Members of the Legislative Audit Commission:

The Minnesota Department of Transportation spends large amounts of public money every year to manage, maintain, and improve our state's highways and other transportation infrastructure.

For some decisions, there is little evidence that the department systematically analyzes the financial consequences of its actions. For others, the department has implemented or is implementing useful policies and procedures to assess its planned actions, some of which have led to significant cost savings. We present several recommendations for the department to improve its measurement of cost-effectiveness.

Our evaluation was conducted by David Kirchner (project manager) and Jessica Obidike, with assistance from Madeline Welter. The Minnesota Department of Transportation cooperated fully with our evaluation, and we thank them for their assistance.

Sincerely,

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Summary

Key Facts and Findings:

- Financial effectiveness in transportation decision making is intrinsically difficult to measure. (p. 7)
- Formal benefit-cost analysis can provide important information to decision makers, but also has significant drawbacks. (pp. 12-18)
- The Minnesota Department of Transportation (MnDOT) rarely uses benefit-cost analysis at the project level; when it is used, it may not affect decision making. (pp. 35-37)
- MnDOT's planning and project selection processes inconsistently address cost-effectiveness. (pp. 22-27)
- MnDOT does not document how it decides among possible alternatives to its project scoping decisions, making it difficult to assess their financial effectiveness. (p. 32)
- MnDOT is promoting new, more financially effective design principles, but it is not ensuring its engineers consistently follow the new approaches. (pp. 39-41)
- Value engineering, a process where a team of outside engineers reviews the design of planned projects, has led to significant cost savings. (pp. 44-46)
- MnDOT does not systematically assess the cost-effectiveness of most maintenance activities, nor has it gathered the performance data it would need to do so. (pp. 52-55)
- However, MnDOT is developing a new database of infrastructure components and their conditions that could improve maintenance decision making. (pp. 55-56)
- A law requiring MnDOT to report on financial "efficiencies" is not useful for assessing the department's financial effectiveness. (pp. 10-11)

Key Recommendations:

- To optimize financial effectiveness, MnDOT decision makers should consistently assess both short-term and long-term outcomes, and both state costs and public impacts. (p. 20)
- MnDOT should reexamine how and why it uses benefit-cost analyses to inform decision making. (pp. 37-38)
- MnDOT should develop guidance on when and how to assess financial effectiveness in its planning processes. (p. 24)
- MnDOT should consider addressing cost-effectiveness more directly in its project scoping documentation. (p. 38)
- MnDOT should develop processes to ensure that district offices follow its new, more cost-effective design principles. (p. 41)
- MnDOT should move forward with efforts to improve the cost-effectiveness of its maintenance decisions. (p. 56)
- The Legislature should reconsider its requirement that MnDOT report on financial "efficiencies." (p. 11)

MnDOT's assessments of its financial effectiveness are inconsistent.

Measuring financial effectiveness in transportation spending is difficult.

Report Summary

In Fiscal Year 2018, the Minnesota Department of Transportation (MnDOT) spent just over $2.1 billion constructing, reconstructing, repairing, and maintaining the state's trunk highway system.

It is important that MnDOT use the large sums of money it receives as effectively as possible. But determining what constitutes an "effective" use of financial resources is complicated.

Measuring financial effectiveness requires assessments of long-term outcomes and public impacts.

We interpreted "financial effectiveness" to mean that the state gets as much benefit as it can for each dollar spent. But MnDOT's spending ideally results in public benefits—traffic flow, safety, access, improvements for business and tourism, and others—that can last for decades and are difficult to quantify.

A key approach to measuring financial effectiveness is benefit-cost analysis. Importantly, benefit-cost analyses address both the short-term and the long-term outcomes of decisions, and consider both state costs and public impacts.

However, such analyses are complex, reliant on predictions of the future, and unable to address some factors that are important to stakeholders. Thus, there are good reasons to limit their use.

We do not expect MnDOT to use a benefit-cost analysis for all decisions. However, to be financially effective, MnDOT decisions should use available evidence to assess the key components of benefit-cost analysis: short-term state costs, short-term public impacts, long-term state costs, and long-term public impacts.

A law requiring MnDOT to report on financial "efficiencies" does not meaningfully measure MnDOT's financial effectiveness.

Each year, MnDOT has reported its progress implementing "efficiencies," as required by state law.

As required by the law, MnDOT's reports only identify decisions that saved money. The reports have not identified decisions that led to cost overruns or other unanticipated spending. A listing limited solely to cost-saving decisions does not provide a complete picture of MnDOT's overall performance in pursuing financial effectiveness. However, requiring MnDOT to assess all of its decisions would be infeasible.

The Legislature should reconsider the requirement that MnDOT identify and report on financial "efficiencies," and instead require MnDOT to provide more meaningful information.

MnDOT inconsistently considers financial effectiveness criteria in its planning and project selection processes.

MnDOT develops—or cooperates with others to develop—many plans, ranging from statewide plans to local plans that focus on individual cities or highway corridors. Some of these plans use detailed benefit-cost analyses; some do not mention costs at all. MnDOT should develop guidance on the analysis of cost-effectiveness in planning studies.

An important step in MnDOT's standard project selection process is the use of computer models to develop initial project lists. These initial lists are then modified by MnDOT's eight district offices.

The computer models do not directly account for the long-term public impacts

of project selection decisions. For example, the benefits from a full highway reconstruction could last decades. In contrast, repeated overlays of new pavement on top of old could produce similar pavement smoothness—but would have far more impact on the traveling public through the cumulative effects of repeated construction delays. MnDOT's computer models do not take such impacts into account.

MnDOT's computer model for bridge projects also does not address long-term state costs. Further, although it incorporates immediate construction costs, it does not analyze how different options would affect MnDOT's long-term maintenance costs.

MnDOT should consider adjusting the models to include these factors. MnDOT is currently revising its pavement model in a way that may address this recommendation.

MnDOT's project scoping documentation is insufficient for assessing the cost-effectiveness of scoping decisions.

Scoping is the process of deciding what will be built—for example, whether a road repaving project will also include replacing drainage structures or adding turn lanes at intersections.

MnDOT's scoping documents generally focus on the project team's final decisions. They do not compare the final configuration with rejected alternatives, nor do they explain the basis for decisions.

Projects that require detailed environmental reviews do document such comparisons. Our examination of a sample of such projects suggested that MnDOT project teams vary in their consideration of financial effectiveness criteria when making scoping decisions. For example, some environmental documents we reviewed included project-level benefit-cost analyses. However, discussions of the final scoping decisions did not always take those analyses into account.

MnDOT should consider developing better documentation of the financial elements that influence its project scoping decisions.

MnDOT has introduced more cost-effective design approaches, but has not enforced their use.

In the design process, designers determine exactly how each element of the project will be built, creating detailed plans and specifications that contractors follow during construction.

Following the lead of other states, MnDOT has introduced "performance-based practical design." This design approach focuses on each location's unique context, rather than following standards that apply to all projects. For example, standards may call for eight-foot wide shoulders in a particular location, but designers may conclude that the existing four-foot wide shoulders have worked well and do not need to be widened.

MnDOT has directed that employees across the department use the new design principles. However, central office design specialists told us that some district-level MnDOT engineering staff are resistant to the new cost-saving approaches. In some cases, local opposition to new design principles may limit MnDOT's options; by law, local municipalities must consent to MnDOT's designs before certain construction projects can begin within their boundaries.

Because the new design approaches have the potential to lead to significant cost savings, MnDOT should create

MnDOT measures state costs and public impacts inconsistently in many decision-making processes.

MnDOT has not measured the financial effectiveness of most maintenance activities, but a new information system may bring changes.

procedures to ensure that district-level staff will implement its new design principles.

"Value engineering" studies—comprehensive external reviews of planned projects—have a strong track record of cost savings.

MnDOT requires these special reviews of all projects expected to cost at least $20 million. Our review of a sample of these studies suggested that they have consistently led to cost-saving suggestions that can reduce project costs by hundreds of thousands of dollars.

Although these studies were valuable, they often focused heavily on construction costs. MnDOT should consider adjusting the studies so they pay more attention to long-term outcomes.

MnDOT has not historically used cost-effectiveness as a basis for prioritizing and planning maintenance activities.

Maintenance activities include both infrastructure repairs and services like snow removal and vegetation mowing.

Historically, MnDOT has not maintained the information needed for effective long-term planning of many of its maintenance activities. MnDOT has not developed a complete inventory of all the infrastructure it is responsible for maintaining, kept integrated performance data showing the outcomes of maintenance activities, or tracked detailed spending information.

Maintenance decisions are made almost entirely by district-level staff and are focused on observed or reported problems. As new problems occur, maintenance crews reshuffle their existing plans to incorporate the needed work.

Budgeting for maintenance activities has not been tied to performance outcomes. MnDOT funds district maintenance offices based on historical formulas, not on evaluated needs and estimated costs.

A new MnDOT database could transform maintenance planning and decision making.

MnDOT has been developing a Transportation Asset Management System (TAMS). This database will track the condition of many highway infrastructure components—such as retaining walls, overhead signs, lighting, highway ramp meters, noise walls, and pedestrian structures—for which MnDOT has never previously kept data. TAMS will also track maintenance spending at a new level of detail.

If the new database works as planned, MnDOT maintenance offices will have access to a wealth of data that was not previously available. Eventually, the department should be able to develop performance benchmarks based on the data and create statewide maintenance priorities informed by long-term costs and outcomes.

We recommend that MnDOT continue its efforts to develop more cost-effective planning and budgeting processes for its maintenance activities.

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Introduction

The Minnesota Department of Transportation (MnDOT) oversees the state's trunk highway network—roads designated as interstates, U.S. Highways, and Minnesota Highways—and makes spending decisions regarding improvements, rehabilitation, and maintenance. Some legislators have raised concerns regarding whether MnDOT is spending public dollars in a cost-effective manner.

In March 2018, the Legislative Audit Commission directed the Office of the Legislative Auditor to evaluate the financial effectiveness of MnDOT's transportation decisions. We addressed the following questions:

- **To what extent does MnDOT use financial effectiveness as a criterion when making decisions about transportation spending?**

- **When MnDOT does assess financial effectiveness, how does it do so? Does the department consider all appropriate costs and benefits?**

To learn how MnDOT incorporates financial considerations in its transportation decisions, we examined state and federal law and interviewed staff in a variety of MnDOT divisions. We spoke with senior project planners and economic analysts, pavement and bridge administrators, construction program managers, senior leadership in the maintenance office, and district maintenance staff, among others.

We examined numerous MnDOT reports, guidance, and studies. We reviewed MnDOT maintenance reports and guidelines for benefit-cost analyses, pavement design, and project selection. We also reviewed several MnDOT long-range planning studies, including selected statewide and local planning documents.

To evaluate how MnDOT makes project-level decisions, we selected a sample of 30 major highway construction projects from MnDOT's 2015, 2016, and 2017 *Major Highway Projects* reports.[1] We chose a variety of projects, including pavement and bridge preservation projects, expansion projects, and safety projects both in the Twin Cities metropolitan area and greater Minnesota. For each project, we examined available scoping, design, and environmental review documents; life-cycle cost analyses; benefit-cost analyses; value engineering studies; and contracting documentation.

We reviewed literature to identify recommended practices associated with conducting economic analyses. We collected and reviewed studies and guidance from a number of sources, including transportation industry leaders such as the American Association of State Highway and Transportation Officials, the Transportation Research Board, the Federal Highway Administration, and academic journals. Finally, we contacted experts at the Volpe National Transportation Systems Center and state transportation agencies in three

[1] Minnesota Department of Transportation, *Report on Major Highway Projects, Trunk Highway Fund Expenditures, and Efficiencies* (St. Paul, 2015); Minnesota Department of Transportation, *Report on Major Highway Projects, Trunk Highway Fund Expenditures, and Efficiencies* (St. Paul, 2016); and Minnesota Department of Transportation, *Major Highway Projects, Trunk Highway Fund Expenditures and Efficiencies Report* (St. Paul, 2017).

other states to learn about how they incorporate financial considerations in their transportation decisions.

We focused on the extent to which MnDOT itself evaluates the cost-effectiveness of its decisions. We did not independently assess the fiscal or public impacts of MnDOT's planning, construction, or maintenance activities. Further, we focused exclusively on decisions related to Minnesota's highway network, MnDOT's largest responsibility.

Chapter 1: MnDOT Overview

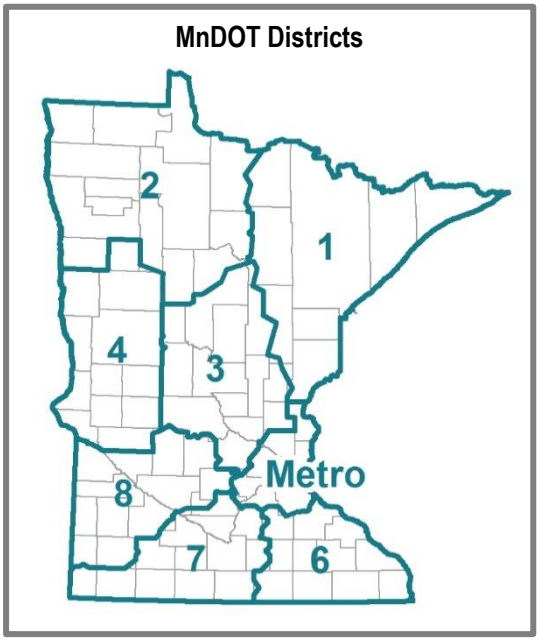
In the 2018-2019 biennium, the Minnesota Department of Transportation (MnDOT) received a total of $7.4 billion in state and federal appropriations, not including bond funds. While financial effectiveness is a high priority for all state agencies, it is particularly important for a department that receives and spends such a large amount of public money. MnDOT's largest and most prominent responsibility is the construction, maintenance, and management of Minnesota's 11,700-mile trunk highway system.[1]

This chapter provides some basic background information on MnDOT and its work.

Organizational Structure

MnDOT has a decentralized organizational structure. Eight district offices are responsible for different regions of the state. Central office units are located in the Twin Cities. Important decisions related to MnDOT spending are made at both the district and central office levels.

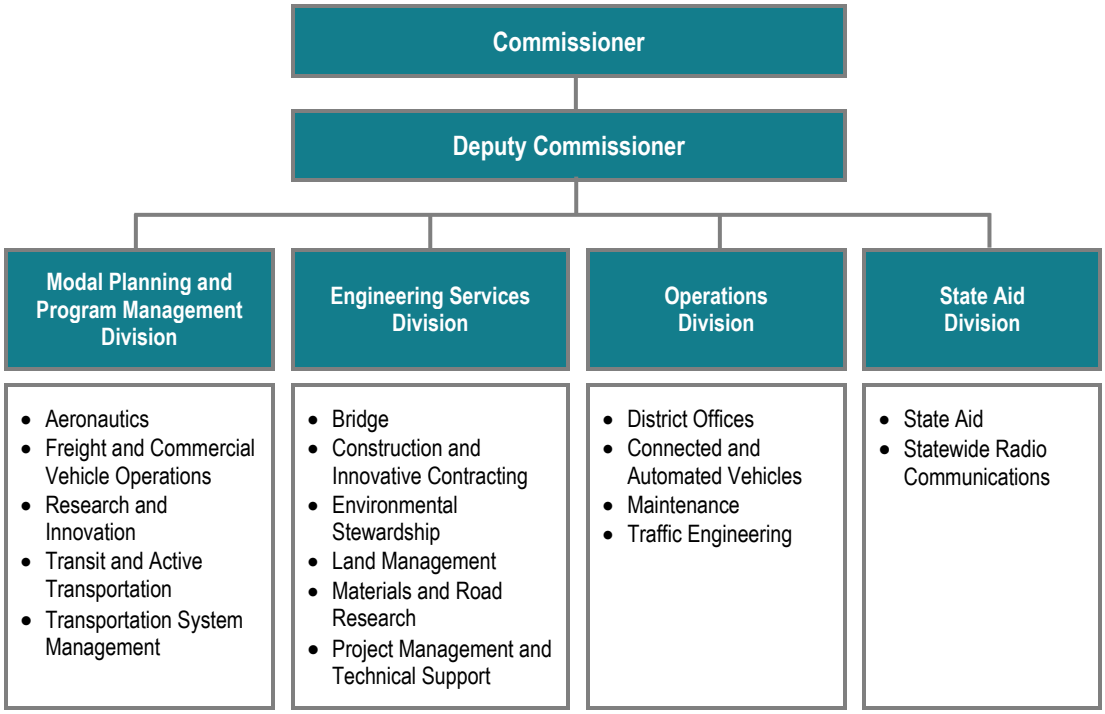
District offices manage nearly all highway construction projects and provide ongoing maintenance and services. Most routine decisions regarding MnDOT's highway spending are made at the district level. In theory, MnDOT central office leadership has the authority to override any district-level decision. But in practice, central office oversight activities are limited, and district staff have autonomy to make many decisions.



Central office units make key decisions regarding the distribution of funding to districts, thus constraining districts' decision-making options. In addition, many central office units have specialized expertise that range from construction planning to maintenance. Central office units often offer this expertise in an advisory or supportive capacity to district decision makers. However, some district actions require approval from one or more central office units before construction work can move forward. For example, MnDOT's State Design Engineer must approve construction project designs if districts seek certain exceptions to MnDOT's design standards.

[1] Trunk highways are all roads under MnDOT's authority, including interstates, U.S. highways, and state highways. Miles here are counted as "centerline" miles, which measure the length of roadways regardless of the number of lanes.

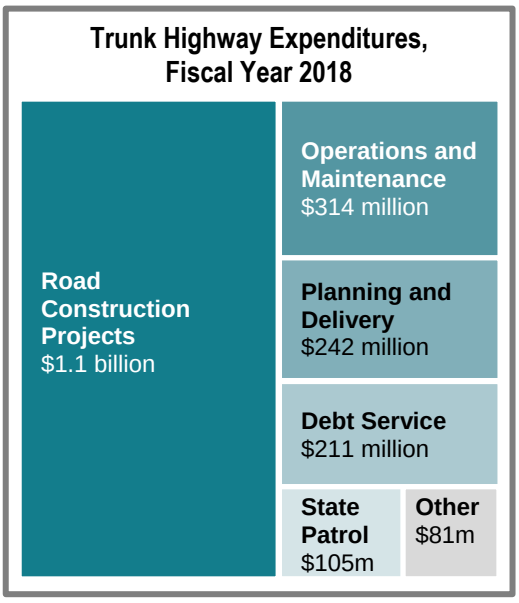
The chart below shows how several divisions and office units that we refer to later in this report are organized within MnDOT's central office.[2] The *Modal Planning and Program Management Division* contains the Office of Transportation System Management, MnDOT's planning office. Its staff are in part responsible for developing the benefit-cost analysis guidance we discuss in Chapter 2 and some of the planning and project selection activities we discuss in Chapter 3. The *Engineering Services Division* encompasses a number of specialty offices. The Bridge and Materials and Road Research offices play important roles in project selection. The Environmental Stewardship Office provides guidance for the development of environmental documents, which we discuss in Chapter 4. We also discuss in Chapter 4 the work of the Design Support units, which fall under the Office of Project Management and Technical Support. The *Operations Division* includes MnDOT's Maintenance Office, whose work we discuss in Chapter 5.



Funding

In Fiscal Year 2018, trunk highway funding from all sources added up to just over $2.1 billion. Transportation taxes—such as fuel, registration, and automobile sales taxes—constituted 62 percent of this total, federal aid provided 29 percent, and 5 percent came from bonding. Smaller sources of revenue included fees, investments, penalties and fines, sales of equipment and services, and payments from local governments for work MnDOT conducted on their behalf.

[2] The figure represents MnDOT's organizational structure at the start of January 2019, before the appointment of a new MnDOT Commissioner. It excludes primarily administrative offices such as MnDOT's finance, legal, and human resources offices.



MnDOT used the majority of this funding to deliver highway construction projects. As shown in the chart at left, MnDOT paid $1.1 billion directly on road and bridge construction projects. In addition, MnDOT spent a large portion of the expenditures labeled "Planning and Delivery" in the chart on work related to construction projects.[3]

MnDOT devoted another $314 million in trunk highway funding to operations and maintenance. This category includes inspections and repair of highway infrastructure, snow and ice removal, roadside infrastructure work, operation and maintenance of traffic signals and signs, and equipment and vehicle costs. The department also spent $211 million on the debt service for bonds used for previous projects. The Legislature appropriated just over $100 million in trunk highway funds directly to the Department of Public Safety, nearly all of which supported the work of the State Patrol.[4]

Managing Minnesota's Highways

MnDOT manages the trunk highway system through a series of key processes. We provide below a brief description of the processes we refer to throughout this evaluation.

Planning. Plans are long-range studies that envision future transportation activities and infrastructure. MnDOT leads the development of some plans; for others, local or regional jurisdictions lead the planning effort and MnDOT is merely a participant. Plans exist at all levels, from system-level plans that address the entire state to corridor plans that address a specific local highway segment. Large-scale plans, such as the state highway plan, tend to set broad goals that are not tied to specific improvements. Regional and local plans, on the other hand, often identify and prioritize specific projects. Plans are key first steps toward modifying or expanding transportation infrastructure. Although MnDOT may not build all the improvements envisioned in system-level or regional plans, it rarely builds anything that is *inconsistent* with existing plans.[5]

Project Selection. To decide what work to do, MnDOT draws from plans and from its assessment of existing infrastructure. MnDOT delivers most infrastructure modifications, expansions, or major rehabilitations through "projects," or bundles of construction work that are contracted out to private firms. The process of deciding which projects to pursue

[3] According to an expenditure breakdown provided by MnDOT, it spent 44 percent of the nonbonding funds allocated to "Planning and Delivery" directly on development and management of highway construction projects. In addition, several other subcategories within Planning and Delivery relate to administrative and staff expenses that apply partially to construction projects.

[4] *Laws of Minnesota* 2017, First Special Session, chapter 3, art. 1, sec. 4. "Other" trunk highway expenses listed in the chart included agency services, buildings, electronic communications, and multimodal activities.

[5] MnDOT might act counter to existing plans if state or federal laws set new priorities that are inconsistent with those plans.

and when to pursue them is a shared responsibility of MnDOT's district offices and central office.[6] MnDOT develops two key project selection documents: (1) the State Transportation Improvement Program (STIP), a definite list of projects scheduled one to four years into the future; and (2) the Capital Highway Investment Plan (CHIP), a tentative list of projects scheduled five to ten years into the future.

Scoping. Once a project is selected for future construction, district staff develop a project's "scope," the components that will be part of the final project. In the scoping process for a rural highway pavement project, for example, MnDOT would identify the specific starting and ending points of the project and decide whether to fully reconstruct the road, simply overlay a new pavement layer on the old one, or pursue some intermediate approach. MnDOT staff might also expand the scope to add repairs of culverts that carry water underneath the road or add traffic controls at an intersection where traffic has increased. Scoping decisions may draw on many sources of information, including traffic forecasts, environmental reviews, input from stakeholders and the public, reports from maintenance crews, and cost estimates.

Design. Design decisions specify exactly how each project component will be built. A scoping decision, for example, may decide to add traffic controls at an intersection, but designers work out the details of that decision. For example, designers may decide the controls will be stop signs with flashing lights, and that lanes will be separated by short medians where they meet the intersection. They may then specify the exact dimensions of the medians and the construction materials to be used. The design process produces a complete set of plans and specifications for the project so that contractors bidding on the project know exactly what the work will involve.

Contracting. MnDOT contract specialists review project plans and specifications and develop final cost estimates. MnDOT then advertises the project, and contractors may bid (submit price proposals) to do the work. Ordinarily, MnDOT awards the contract to the contractor that proposes the lowest price and meets the project's requirements. MnDOT also uses some alternative processes for awarding contracts; we describe these in Chapter 4.

Construction. The contractor builds the project in the construction phase. MnDOT staff monitor the construction to ensure that the work is done according to MnDOT's plans and specifications and that the contractor follows various legal requirements.

Maintenance. Maintenance is the work MnDOT does on existing infrastructure to keep it in effective operating condition. Maintenance encompasses repairs to pavements, bridges, drainage structures, signs, fences, and many other infrastructure elements. It also includes tasks such as snow and ice removal, responding to crashes and other emergencies, managing vegetation, and removing debris and graffiti.

[6] We described the project selection process in detail in Office of the Legislative Auditor, Program Evaluation Division, *MnDOT Highway Project Selection* (St. Paul, 2016). Although the Legislature and MnDOT made some changes to the process in response to our report, the overall framework described in that report remains the same.

Chapter 2: Measuring Financial Effectiveness

The purpose of transportation spending is to provide benefits to the general public. Therefore, MnDOT's financial effectiveness is based on both how much the department spends and the value the public receives as a result of its actions.

Measuring the financial effectiveness of a transportation department's activities is inherently challenging.

Measuring the amount MnDOT spends on a single construction project is relatively straightforward. But the value Minnesotans receive from the project may include many intangible benefits, such as access, safety, reliability, comfort, and aesthetics. Such benefits are not easy to quantify, especially given the differing needs of Minnesota's residents. Further, MnDOT must balance financial criteria with other important missions, such as supporting economic growth, protecting the environment, encouraging tourism, and maintaining a skilled departmental workforce. Decisions that promote some of these other goals may sometimes cost more than cheaper alternatives, but that does not necessarily make them unwise.

Below, we describe how we defined financial effectiveness and the extent to which state law requires MnDOT to measure it. We then discuss benefit-cost analysis, a comprehensive approach to assessing financial effectiveness that nonetheless is insufficient in many circumstances. After describing such analysis generally, we consider MnDOT's standard methodology for benefit-cost analysis. Finally, we draw some general principles from the benefit-cost literature that we use in the remainder of this evaluation.

Definition

The concept of financial effectiveness does not have one universally accepted definition in transportation policy circles. There are several ways to think about financial effectiveness. For example: (1) Is MnDOT getting as much societal benefit as it can with the funds available? (2) Is MnDOT directing its spending towards locations or populations where it will have the largest positive impact? (3) Is MnDOT spending the least amount of money possible while addressing transportation needs?

Each of the above questions emphasizes slightly different elements of a larger picture, and it would be possible to write many other questions illuminating other facets of the concept of "financial effectiveness." We focused on a definition that addresses the first question above.

We interpreted "financial effectiveness" to mean that the state gets as much benefit as it can from each dollar spent.

This interpretation of financial effectiveness is consistent with state law, which states that a goal of the state transportation system is "to maximize the long-term benefits received for

each state transportation investment."[1] State law further directs MnDOT to "prevent the waste or unnecessary spending of public money" and to "use innovative fiscal and human resource practices to manage the state's resources and operate the department as efficiently as possible" as part of the department's overall mission.[2]

Using our interpretation, MnDOT can increase financial effectiveness by reducing costs while accomplishing equivalent outcomes. However, financial effectiveness is not limited to strategies that save money. For example, it would be financially effective for MnDOT to reorganize a project's construction schedule to reduce the time traffic must be detoured, even if MnDOT spends the same amount. Although MnDOT does not save money in its own budget, it provides greater benefits to the public for the same amount of spending. It may even be financially effective for MnDOT to increase its costs if the resulting benefits to the public are disproportionally high.

Legal Guidance

Most of the laws addressing MnDOT's stewardship of state funds are quite general.

State laws require MnDOT to be financially effective, but the statutory language is broad and open to interpretation.

State transportation law directs MnDOT to address financial effectiveness in its large-scale planning processes. However, because the plans cover many years of prospective projects, improvements, and operations, MnDOT only addresses these mandates broadly.

For example, the statewide transportation plan must "evaluate all transportation programs and facilities proposed for inclusion in the plan in terms of economic costs and benefits…."[3] However, since the law's original passage in 1976, MnDOT has interpreted this provision to apply to system-wide costs and benefits, and not to the characteristics of individual projects.[4] Additional provisions of the law suggest that the Legislature did not anticipate that individual projects would appear in the plan. The law directs MnDOT to develop "statewide transportation priorities" based on the plan, and only then "schedule authorized public capital improvements and other authorized public transportation expenditures pursuant to the priorities."[5] Further, MnDOT has developed a "family" of transportation plans since the law's original passage, including a statewide 50-year vision, a statewide multimodal transportation plan, and separate plans for individual transportation modes (highways, aviation, rail, bicycles, etc.). As such, it is unclear how to interpret the provision mandating benefit-cost evaluations of programs and facilities included "in the plan."

State law also requires that MnDOT's state highway investment plan identify "strategies to ensure the most efficient use of existing transportation infrastructure, and to maximize the

[1] *Minnesota Statutes* 2018, 174.01, subd. 2(8).

[2] *Minnesota Statutes* 2018, 174.02, subd. 1a.

[3] *Minnesota Statutes* 2018, 174.03, subd. 1(2).

[4] *Laws of Minnesota* 1976, chapter 166, sec. 3.

[5] *Minnesota Statutes* 2018, 174.03, subd. 1(3).

performance benefits of projected available funding."[6] As the law requires, the state highway plan addresses using available funding to maximize performance benefits.[7] However, the performance benefits considered are at a system-wide level, such as the statewide percentages of pavement and bridges in poor condition. As a result, the highway plan's financial strategies to promote efficiency and maximize performance are system-wide, not project-specific.

In addition, state law requires all executive branch agencies, including MnDOT, to develop and present performance data on overall program goals and objectives as part of the state budget process. Agency budget proposals should "strengthen accountability to Minnesotans by providing a record of state government's performance in providing effective and efficient services."[8] However, the law does not specify what performance measures agencies should provide or at what level of detail.

Few legal requirements address how MnDOT should pursue or measure financial effectiveness in its routine activities.

The few laws that address MnDOT's financial effectiveness for project-level or day-to-day decisions tend to be quite specific, applying only to small pieces of the department's overall work. For example, two legislatively created highway programs, Corridors of Commerce and the Transportation and Economic Development (TED) program, require that MnDOT select projects for funding using specified economic analysis measures.[9] Projects funded by these programs constitute a small fraction of MnDOT's highway projects.

Another law requires that MnDOT use a life-cycle cost analysis—a tabulation of total costs, including immediate construction costs and long-term maintenance and rehabilitation costs—to compare pavement types for each project involving the reconditioning, resurfacing, or repair of pavement.[10] MnDOT typically selects the pavement alternative with the lowest life-cycle costs. Such projects constitute 49 percent of MnDOT's budget for road construction. However, the required analysis addresses only one of the many decisions made throughout a project's scoping, design, and construction stages. For example, MnDOT determines how wide to build the highway shoulder, which can significantly affect pavement costs, before conducting the life-cycle cost analysis to determine what pavement type to use. We discuss life-cycle cost analyses further in Chapter 4.

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[6] *Minnesota Statutes* 2018, 174.03, subd. 1c(6).

[7] Minnesota Department of Transportation, *20-Year State Highway Investment Plan 2018-2037* (St. Paul, 2017). More precisely, the plan assessed the performance outcomes of different investment combinations—for example, if MnDOT spent more toward improved safety outcomes, it might spend less on preserving existing infrastructure.

[8] *Minnesota Statutes* 2018, 16A.10, subd. 1a(3).

[9] MnDOT must evaluate potential Corridors of Commerce projects using "a return on investment measure that provides for comparison across eligible projects." *Minnesota Statutes* 2018, 161.088, subd. 5(c)(1). Selection of TED projects must be based on "the extent to which the project provides measurable economic benefit." *Minnesota Statutes* 2018, 174.12, subd. 5(1).

[10] *Minnesota Statutes* 2018, 174.185.

A legislative mandate that MnDOT report on financial "efficiencies" is not useful for assessing the department's financial effectiveness.

The 2017 Legislature required MnDOT to "implement efficiencies equal to at least 15 percent of the appropriations made annually to the commissioner from the trunk highway fund that are above base appropriations for fiscal years 2018 and 2019."[11] This legislation was preceded by a similar law passed in 2014.[12]

The term "efficiency" is not defined in law, but both laws' texts implicitly equated efficiencies with cost savings, and the 2017 law directed that MnDOT spend all money saved through implemented efficiencies on highway construction or maintenance.[13] MnDOT must report each year on all money saved through efficiencies during the previous two fiscal years.[14]

Spotlight: Nine Mile Creek Bridge, Minnetonka (Highway 169)

MnDOT's report on efficiencies for Fiscal Year 2017 included $11.8 million in savings on the Nine Mile Creek bridge project. Most of these savings ($9.8 million) came from the decision to build a causeway instead of a traditional bridge.

The decision to build the causeway was a cost-effective one. The causeway was cheaper to build, caused fewer wetland impacts, will require less long-term maintenance work, and is more easily expandable to six lanes than a traditional bridge.

To meet the law's requirements, MnDOT staff have annually conducted a wide-ranging effort to identify past changes in agency practices or individual projects with money-saving outcomes in the current fiscal year. MnDOT has estimated how much money those changes have saved and reported those results to the Legislature, as illustrated in the example at left.

However, the report the Legislature required MnDOT to produce is incomplete. MnDOT only identified successes—instances where the department had spent less money than it would have otherwise. MnDOT staff did not attempt to identify any instances where the department had spent more money than anticipated because of cost overruns or poor decision making. For example, in October 2017, the Geometric Design Support Unit within the Office of Project Management and Technical Support pointed out unnecessary costs in a memorandum to a District 8 project manager regarding a project planned for Highway 12:

> We believe that there were additional opportunities within this project to apply the Road Design Manual, Technical Memoranda, and Performance-Based Practical Design principles consistent with departmental policy. These opportunities would have resulted in reduced capital costs, increased driver and pedestrian safety, [and] reduced long-term operation and

[11] *Laws of Minnesota* 2017, First Special Session, chapter 3, art. 3, sec. 101, codified as *Minnesota Statutes* 2018, 174.53.

[12] *Laws of Minnesota* 2014, chapter 312, art. 11, secs. 26 and 33, partially codified in *Minnesota Statutes* 2018, 174.56, subd. 1(a).

[13] *Minnesota Statutes* 2018, 174.53(b).

[14] *Minnesota Statutes* 2018, 174.56, subd. 1(a).

> maintenance costs while exceeding stakeholder expectations and meeting District needs.[15]

The law did not require MnDOT to include in its efficiencies report the extra costs added by this district decision—which would offset the savings it reported on other projects.

RECOMMENDATION

The Legislature should reconsider its requirement that MnDOT report on financial "efficiencies."

MnDOT's reports to the Legislature—although consistent with the law's requirements—are simply listings of past decisions that resulted in lower costs. Because decisions that resulted in higher costs are not included, the report presents an incomplete and therefore unhelpful picture of MnDOT's financial decision making.

However, mandating that MnDOT produce a comprehensive report that assesses all of its decisions is infeasible. Given the multiple factors involved in many spending decisions, such a reexamination across hundreds of projects and thousands of decisions each year would be unrealistically time-consuming.[16]

The Legislature should rethink its approach. Several options are possible. For example, the Legislature could mandate that MnDOT choose a small sample of projects and report on the cost-effectiveness of *all* decisions associated with each project. Another method would be to choose a certain type of decision—design decisions, for instance—and direct that MnDOT report on the cost-effectiveness of all such decisions within a given time period.

Yet another option would be to require the department to develop specific new cost-saving strategies and then report on their implementation. However, because MnDOT makes many decisions years ahead of construction, this approach would require the Legislature to be patient in awaiting the outcomes of the new strategies. For example, the 2019 Legislature could require the department to report back to the 2020 Legislature on cost-saving changes it will implement for projects beginning construction in Fiscal Year 2023. MnDOT could then be required to report again after Fiscal Year 2023 to demonstrate whether it achieved the financial goals it had set several years earlier.

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[15] State Geometrics Engineer, Minnesota Department of Transportation, memorandum to Project Manager, *SP 3403-74 Layout No. 1, TH 12 in the vicinity of the City of Willmar, Geometric Layout Staff Approval*, October 2, 2017.

[16] We also note that determining what a project *would have cost* had MnDOT not made a cost-saving (or cost-increasing) decision is inherently speculative.

Benefit-Cost Analysis

One technique to assess whether MnDOT provides enough value to the public for the money it spends is a benefit-cost analysis, also called a cost-effectiveness analysis or return-on-investment analysis.[17]

Benefit-cost analysis provides an important framework for formally assessing the financial effectiveness of transportation projects, but it has significant limitations.

A benefit-cost analysis assigns a monetary value—either positive or negative—to all expected outcomes of a policy, decision, or action.[18] Usually, the short-term costs borne by the transportation agency (such as construction costs) are the most straightforward values to assign. Assigning monetary values to longer-term benefits received by the public, such as faster travel times or increased safety, is more challenging.

For example, in many benefit-cost analyses, the largest benefit gained from a transportation project is "travel time savings," the aggregated amount of time that travelers do not spend traveling because the improvement has increased travel speeds or reduced congestion. To assign values to this benefit, many economists have carried out studies to assess the value that people place on their time. The Federal Highway Administration (FHWA) and MnDOT have drawn upon this literature to develop standardized monetary values for time savings to be used in benefit-cost analyses.

Analysts tabulate all of the benefit and cost amounts over an analysis period, often at least 20 or 30 years into the future (and sometimes as long as 60 years). A proposed action is considered reasonable if total expected benefits are greater than expected costs. Further, when comparing multiple alternatives, the one with the highest ratio of benefits to costs is considered the most cost-effective. In most benefit-cost analyses, the proposed action is compared to a "base case" or "no-build" scenario—in other words, a project is only cost-effective if it performs better than maintaining the status quo. We describe a hypothetical benefit-cost analysis using MnDOT's standard methodology (which we discuss below) in Exhibit 2.1.

[17] MnDOT considers benefit-cost, cost-effectiveness, and return-on-investment analyses to be essentially synonymous, and we follow that approach in this report. However, some authors treat these terms as having slightly different meanings.

[18] We provide here a very abbreviated description of benefit-cost analysis techniques. A voluminous literature exists on transportation benefit-cost analysis methods. See, for example, U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* (Washington, DC, 2018); Louis-Étienne Couture, Shoshanna Saxe, and Eric J. Miller, *Cost-Benefit Analysis of Transportation Investment: A Literature Review*, University of Toronto Transportation Research Institute Report #16-02-04-01 (Toronto, 2016); Michael J. Markow, *Engineering Economic Analysis Practices for Highway Investment: A Synthesis of Highway Practice*, National Cooperative Highway Research Program Synthesis 424 (Washington, DC: Transportation Research Board, 2012); and American Association of State Highway and Transportation Officials, *User and Non-User Benefit Analysis for Highways* (Washington, DC, 2010). For criticisms of standard transportation benefit-cost methodology, see Karel Martens and Floridea di Ciommo, "Travel Time Savings, Accessibility Gains, and Equity Effects in Cost-Benefit Analysis," *Transport Reviews* 37, no. 2 (March 2017): 152-169; and David Metz, "The Myth of Travel Time Saving," *Transport Reviews* 28, no. 3 (May 2008): 321-336.

Exhibit 2.1: A Hypothetical Benefit-Cost Analysis Using MnDOT's Standard Methodology

Proposed Project

A commercial area lies two miles from an interstate. The two-lane trunk highway connecting the commercial area to the interstate is frequently congested. The proposed project would convert the two-lane highway to a four-lane highway. Estimated construction cost (including land purchases) is $25 million. Our benefit-cost analysis will assess outcomes over a 20-year period.

Benefits

Travel Time: Current traffic is 23,000 vehicles per day, of which 6 percent are trucks. Average traffic speed is 45 mph. Traffic models predict that in 20 years, traffic will increase to 27,000 vehicles per day at an average speed of 40 mph. If the expansion is built, average traffic speed will increase to 60 mph and stay at that level despite a larger increase in traffic (29,000 vehicles per day). Using MnDOT's standard values for the cost of time ($18.90 per hour for cars and $30.30 per hour for trucks), we multiply out the time costs to travelers over the entire 20-year period under two scenarios—no action (the "no-build" option), and building the expansion (the "build" option).

	"No-Build" costs	"Build" costs	Benefit
Travel Time	$149.7 M	$109.7 M	$40.0 M

Vehicle Operations: In addition to the cost of time, travelers incur costs for fuel and vehicle wear. Further, vehicles create pollution, which has a broader societal cost. Again, we multiply out these costs over a 20-year period using MnDOT's standard values ($0.32 per mile for cars and $0.99 per mile for trucks). Because the new highway will induce additional traffic, overall operating costs will actually be higher if the expansion is built, creating a "negative benefit."

	"No-Build" costs	"Build" costs	Benefit
Vehicle Operations	$116.4 M	$121.1 M	($4.7 M)

Safety: The four-lane highway is expected to be safer than the old two-lane highway. Starting with historical crash data for this road segment, we extrapolate how many more crashes are likely to occur under the "no-build" option as traffic levels increase. To predict crash levels for the new road (the "build" option), we use crash data from other four-lane highways in the same MnDOT district. We multiply out the costs using MnDOT's standard values (ranging from $11.1 million for a crash with a fatality to $7,200 for a crash with property damage only).

	"No-Build" costs	"Build" costs	Benefit
Crashes	$64.0 M	$52.8 M	$11.2 M

Remaining Capital Value: After 20 years, the asphalt road surface on the new lanes will be nearing replacement. However, MnDOT will not need to reconstruct the road's underlying base layers and drainage structures, nor will it need to buy land again. Those investments will still have value at the end of the 20-year period.

	"No-Build" benefits	"Build" benefits	Benefit
Remaining Capital Value	$0	$7.5 M	$7.5 M

Continued next page.

Exhibit 2.1 (continued)

Costs

Construction: As mentioned in the project description above, the projected construction cost is $25 million.

	"No-Build" costs	"Build" costs	Cost
Construction	$0	$25.0 M	($25.0 M)

Maintenance: MnDOT will have to maintain a new highway segment, including minor pavement repairs and snow plowing. We estimate these added maintenance costs over a 20-year period using information from other highways in the district. Because the existing two-lane highway would become part of the four-lane highway, its maintenance costs will be the same in both the "no-build" and "build" options and can be therefore treated as zero.

	"No-Build" costs	"Build" costs	Cost
Maintenance	$0	$2.8 M	($2.8 M)

Bonding: This project would be funded through MnDOT's standard appropriations, so there would be no bonding money involved. If bonding funds were used, we would add the amount of interest paid over the 20-year period to the total costs.

Benefit-Cost Ratio

The benefit-cost ratio is determined by dividing the total estimated benefits by the total estimated costs.

Total Benefits	$54.0 million
Total Costs	$27.8 million
Benefit-Cost Ratio	**1.9**

NOTES: MnDOT's standard values are updated regularly; this exhibit uses the July 2018 values. All monetary values for future years were adjusted using MnDOT's standard "discount rate" of 1.2 percent. Using a discount rate is a standard benefit-cost methodology that accounts for the fact that future spending costs less than if the same amount were spent immediately (because the money could be spent on other projects or invested in the meantime). We made several assumptions to simplify calculations. For example, we assumed that (1) construction would begin in the same year the analysis was performed (so we did not discount construction costs); (2) each vehicle would contain one driver and no passengers; and (3) all induced traffic due to the roadway expansion would be new trips, not trips that would have occurred anyway using different routes. Changing any of these assumptions would likely increase the benefit-cost ratio.

SOURCE: Office of the Legislative Auditor

Because all impacts are theoretically included, benefit-cost analyses provide a comprehensive assessment of a project's overall value. As stated in a bipartisan 2014 U.S. Senate committee report:

> Benefit cost analysis is an important economic tool that can help State and local governments target their transportation funding to the most effective investments…. This process forces the government to evaluate the value of all of the project's benefits, recognize the full cost of the project, and acknowledge whether or not the benefits outweigh the costs.[19]

Despite its comprehensiveness, benefit-cost analysis also has significant drawbacks that limit its usefulness. We discuss these limitations in a separate section below.

MnDOT's Standard Benefit-Cost Model

MnDOT's Performance, Risk, and Investment Analysis Unit has developed a standard benefit-cost methodology for use by the department and its consultants.

MnDOT's standard benefit-cost methodology is conservative, considering only a small set of benefits and costs.

Although models adopted by transportation agencies elsewhere allow for many types of benefits and costs (for example, see the box below), MnDOT limits its model to the three main benefits cited most widely in the benefit-cost literature: travel time savings, reduced vehicle operating costs (such as using less fuel), and crash reduction. In addition, MnDOT's standard methodology also assesses an improvement's remaining infrastructure value—for example, if an improvement's expected life is 30 years, but the benefit-cost analysis period is 20 years, the analysis adds to the projected benefits to account for the additional 10 years of service life. For costs, MnDOT includes the initial construction of the project, ongoing maintenance, and (if applicable) future pavement rehabilitation. MnDOT's model also accounts for the societal cost of additional air pollution due to increased traffic levels; these are incorporated into its value for vehicle operating costs.

Practices in Other States

The California Department of Transportation (Caltrans) uses a robust benefit-cost analysis framework. Unlike Minnesota's standard methodology, it is designed to analyze a wide variety of projects, including highway projects, transit projects, bike and pedestrian improvements, park-and-ride lots, and intermodal freight facilities.

In addition to calculating the same benefits as Minnesota's standard benefit-cost methodology, Caltrans also has developed measures for journey quality, health impacts, and shipper cost savings. A training module posted online in December 2017 indicated that travel time reliability would be added within a few months.

MnDOT's standard benefit-cost methodology produces a ratio—when benefits exceed costs, the ratio is greater than 1.0. When costs exceed benefits, the ratio is less than 1.0.[20] As we describe in Chapter 4, MnDOT has a policy that

[19] U.S. Congress, Senate Committee on Appropriations, *Transportation and Housing and Urban Development, and Related Agencies Appropriations Bill, 2015: Report (to Accompany S. 2438)*, 113th Cong., 2d Sess., 2014, S. Rep. 113-182, 48-49.

[20] The measurement of benefits is calculated by comparing a proposed action to the "no-build" alternative. As a result, MnDOT does not calculate a benefit-cost ratio for the no-build alternative itself. If a proposed project has a benefit-cost ratio less than 1.0, not building the project is considered more cost-effective than building it.

certain projects cannot move forward if a benefit-cost analysis projects a ratio of less than 1.0, unless special considerations exist.

MnDOT maintains and regularly updates standard values for use in benefit-cost analyses produced by MnDOT staff and consultants. These include, for example, a value for the travel time savings per person per hour and values for the costs of auto crash injuries of varying severity.

MnDOT does not routinely incorporate sensitivity analysis, a best practice, into its benefit-cost analyses.

Benefit-cost analyses rely on predictions about the future and involve many assumptions about the value of benefits. To reduce the likelihood that incorrect predictions and assumptions could lead to inaccurate conclusions, a best practice in benefit-cost analysis is to incorporate a "sensitivity analysis."

In a sensitivity analysis, the analyst repeats the analysis multiple times while varying the predictions and assumptions. For example, a sensitivity analysis might ask: what would be the benefit-cost ratio if traffic does not increase as much as predicted? If project costs are significantly higher than expected? If future inflation rates are higher than expected?

If a project alternative continues to have the highest benefit-cost ratio across all changes to predictions and assumptions, project decision makers should have stronger confidence in the results of the benefit-cost analysis. On the other hand, decision makers may gain a more nuanced understanding of the value of different alternatives if changing the assumptions causes different alternatives to score more favorably.

MnDOT's benefit-cost documentation makes only a passing mention of sensitivity analysis, and most MnDOT benefit-cost analyses we reviewed did not use one. In a couple of instances, MnDOT did examine the sensitivity of the analysis to fatal crashes by assigning lower cost values to such crashes.[21] Best practices identified in the benefit-cost literature expect much more robust use of sensitivity analyses.[22]

In response to an inquiry from our office, a MnDOT economic policy analyst suggested two reasons the department does not use sensitivity analyses. First, benefit-cost ratios rarely fall so close to 1.0 that a sensitivity analysis would call into question whether a project is worthwhile. Second, sensitivity analyses are complex and time-consuming, and MnDOT has not invested in computer modeling programs that would make such analyses simpler to perform. He also expressed skepticism that sufficiently rigorous computer software is currently available.

[21] Benefits for safety are calculated using a project location's past crash history. The MnDOT-assigned cost for a traffic fatality dwarfs all other costs. Redoing the analysis with a smaller figure for avoiding fatal crashes can highlight whether a past fatal crash—a fairly rare event in any single location—is disproportionately affecting the entire analysis.

[22] For example, see American Association of State Highway and Transportation Officials, *User and Non-User Benefit Analysis For Highways* (Washington, DC, 2010), 6-66 to 6-67.

RECOMMENDATION

MnDOT should incorporate sensitivity analysis into its standard benefit-cost methodology.

Sensitivity analysis is a well-recognized best practice when conducting benefit-cost analyses. It can make the conclusions of benefit-cost analyses more robust. Conversely, it can also suggest that calculated benefit-cost ratios be treated with some caution. Both outcomes are valuable information for decision makers. MnDOT should use sensitivity analyses in benefit-cost analyses the department performs or oversees.

However, sensitivity analyses can also be time-consuming. Thus, it is important for MnDOT to determine which assumptions to examine critically; a comprehensive sensitivity analysis of *all* factors in a benefit-cost analysis would probably not produce enough valuable information to justify the effort. MnDOT should add a section on sensitivity analysis to its standard benefit-cost methodology that provides guidance on which factors are most important to analyze.

We acknowledge that sensitivity analyses may rarely change whether a proposed project lies above or below MnDOT's 1.0 threshold for an acceptable benefit-cost ratio. However, as we discuss in Chapter 4, MnDOT places undue emphasis on the 1.0 threshold. We are unpersuaded that available software is insufficient; the American Association of State Highway and Transportation Officials has recommended the use of sensitivity analysis since at least 2003.[23]

Limitations

Benefit-cost analyses, despite their value as a tool for comprehensively assessing the cost-effectiveness of transportation investments, have important drawbacks.

First, benefit-cost analyses can be technically difficult to develop, even for transportation professionals. For example, the competitive TIGER transportation infrastructure funding program required state and local government applicants to submit benefit-cost analyses to the U.S. Department of Transportation.[24] Over several funding rounds, the department's reviewers found that nearly two-thirds of 593 submitted benefit-cost analyses were "not useful" or only "marginally useful" due to analytical errors or incomplete data.[25] Complexity also affects the usefulness of benefit-cost analyses for stakeholders and the general public, who may not be familiar with the economic jargon often used in reporting results.

Second, benefit-cost analyses rely on untestable assumptions about the value of nonmonetary costs and benefits. For example, regardless of the rigor of studies that estimate the value travelers place on their time, there is no obvious way to check their conclusions. It would be an impossible task to even locate all the users of a highway

[23] American Association of State Highway and Transportation Officials, *User Benefit Analysis for Highways Manual* (Washington, DC, 2003), 6-62 to 6-64.

[24] TIGER stands for Transportation Investment Generating Economic Recovery.

[25] Anthony C. Homan, "Role of BCA in TIGER grant reviews: common errors and influence on the selection process," *Journal of Benefit-Cost Analysis* 5, no. 1 (2014): 111-135.

segment over a 20-year period, much less determine the value of the total time saved because of a transportation infrastructure project.

Third, there is not a clear consensus among academic experts or transportation agencies regarding what benefits and costs should be counted. Most benefit-cost analyses count construction and maintenance costs on the cost side of the analysis; and travel time savings, vehicle operation savings, and reduced crashes on the benefit side. But academic researchers and government agencies have used many other costs and benefits beyond these common factors, such as travel time reliability (a measure of how often a trip can be completed within a certain time window), travel time savings for transit users, environmental effects on air and water, changes in property values, and increased economic activity. Using different parameters adopted by different governments can produce different results—even to the extent of changing the conclusion of whether a project is cost-effective.

Fourth, benefit-cost analyses rely on predictions of the future. But some predictions will end up being incorrect in ways that would have affected the conclusions of the analysis. Some construction projects will experience cost overruns. Some studies will underestimate or overestimate future traffic demand. Further, future social and technological changes such as changing land use patterns, alternative fuels, increased telecommuting, and climate change may affect the benefits and costs of roadway usage in unforeseen ways.

Fifth, and perhaps most importantly, benefit-cost analyses do not measure certain characteristics that are important to decision makers. A recent federal study observed:

> [A benefit-cost analysis] typically does not address—at least not directly—several issues that have great influence on project prioritization and other decisionmaking. These include local economic impacts and economic development; equity (by region, mode of travel and/or program area); the degree of support from the public and other stakeholders; the ability to leverage external funding sources; and the likelihood of completing a project without delays.[26]

For example, Minnesota policy makers have long agreed to balance transportation investments between the Twin Cities metropolitan area and greater Minnesota. But benefit-cost analyses frequently assign higher values to urban projects than similar rural projects because they benefit more people. The 2017 Legislature required MnDOT to choose projects for the Corridors of Commerce program based heavily on benefit-cost ("return on investment") criteria.[27] Although MnDOT distributed approximately half the funding to projects outside of MnDOT's Metro District, the importance of benefit-cost criteria in the evaluation of projects meant that the top scoring projects in "greater Minnesota" were in highly populated exurban locations just outside of the Metro District boundaries.

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[26] [John A. Volpe National Transportation Systems Center], *Use of Benefit-Cost Analysis by State Departments of Transportation: Report to Congress* ([Washington, DC, 2016]), 40, https://www.fhwa.dot.gov/policy/otps/pubs/bca_report/, accessed May 1, 2018.

[27] *Laws of Minnesota* 2017, First Special Session, chapter 3, art. 3, sec. 21, codified as *Minnesota Statutes* 2018, 161.088, subd. 5. "Return on investment" was one of eight listed criteria, but several of the other criteria measured related characteristics. For example, "improvements to traffic safety" was another criterion. Locations in populous areas will ordinarily achieve greater benefits from safety improvements than locations in less populated areas.

Measurement Guidelines

Because of the technical complexity and analytical limitations of benefit-cost analyses, it is reasonable to avoid overreliance on their use. In fact, the Legislature once required that a benefit-cost analysis be conducted for all transportation contracts greater than $10 million, only to let the law expire two years later.[28]

In our view, however, the underlying framework used in benefit-cost analyses is crucial for measuring financial effectiveness in transportation spending. Even when it does not conduct a formal analysis, MnDOT should assess its activities across two key dimensions used in benefit-cost analyses.

We illustrate both of these dimensions—short-term outcomes compared to long-term outcomes and state costs compared to public impacts—in the two-by-two matrix in Exhibit 2.2. A comprehensive benefit-cost analysis would tabulate costs and benefits in all four quadrants of the matrix: short-term state costs, long-term state costs, short-term public impacts, and long-term public impacts.

Exhibit 2.2: Possible Outcomes of MnDOT Highway Construction Activities

	State Costs	Public Impacts
Short-Term (Before and during construction)	Construction costs	Traffic delays Access limitations Short-term environmental impacts
Long-Term	Maintenance costs Bond servicing costs Future construction costs (if initial fix does not last long)	Travel times Safety Access Smoothness of roadway surface Long-term environmental impacts Business impacts Land use impacts Maintenance-related traffic impacts Future construction-related impacts (if initial fix does not last long)

NOTE: The examples above are illustrative, not comprehensive.

SOURCE: Office of the Legislative Auditor.

[28] *Laws of Minnesota* 2001, First Special Session, chapter 10, art. 2, sec. 41.

RECOMMENDATION

When assessing financial effectiveness, MnDOT should consistently examine: (1) short-term and long-term outcomes, and (2) outcomes for MnDOT and the general public.

Decisions made about repairing, rebuilding, or expanding transportation infrastructure can have continuing effects for decades. Benefit-cost analyses explicitly model these long-term effects, adding up the value of benefits and costs over long periods of time to determine the overall financial effectiveness of a spending decision. Regardless of whether it uses formal benefit-cost analyses in decision-making, MnDOT should analyze long-term outcomes as well as short-term outcomes in order to strive for financial effectiveness. Decisions that may cost more money in the short-term may reap continuing long-term advantages that justify the extra expense.

The purpose of transportation spending is to obtain benefits for the general public; benefit-cost analyses assign monetary values to these outcomes. To strive for financial effectiveness, MnDOT should analyze both state costs and the public impacts of its decisions, even if no formal benefit-cost analysis is employed. In general, alternatives that provide the public more benefits should be preferred to those that provide fewer if costs are similar.

In the following three chapters, we examine many MnDOT decision-making processes. MnDOT does not use formal benefit-cost analyses to make many of these decisions, and we do not necessarily think that it should do so. However, we believe that financially effective decision processes should address all four quadrants of the Exhibit 2.2 matrix in a deliberate, evidence-based manner. To the extent that MnDOT does not analyze all dimensions of financial effectiveness, we make recommendations that MnDOT adjust its decision-making processes.

Chapter 3: Planning and Project Selection

When signs notify motorists that MnDOT will be starting a road construction project, the work that is beginning is often the final outcome of decisions made years, or even decades, earlier. MnDOT's planning activities assess both current transportation needs and expected needs far into the future. These plans form the underlying basis for MnDOT's initial project selection decisions—that is, its preliminary listing of specific projects—which are made up to ten years before the projects begin construction. MnDOT's planning and project selection processes have a significant impact on how MnDOT spends the funds it is allocated, even though the decisions occur long before the spending actually occurs.

In this chapter, we discuss how MnDOT assesses the financial effectiveness of its planning and project selection processes. Our guiding framework relies on the two dimensions of decision making we discussed at the end of Chapter 2: does MnDOT assess short-term and long-term outcomes, and does it assess outcomes for both MnDOT and for the general population? To optimize financial effectiveness, MnDOT should examine outcomes in all four quadrants of the matrix. To the extent feasible, such examinations should be analytic and evidence-based, and not drawn solely from informal professional judgments.

Outcomes MnDOT Should Analyze to Address Financial Effectiveness

Short-term state costs How a decision will affect a project's construction costs	**Short-term public impacts** How a decision will affect the public during construction
Long-term state costs How a decision will affect costs after construction (due to maintenance or reconstruction needs, etc.)	**Long-term public impacts** How a decision will affect the public after construction (by altering travel times, access, safety, etc.)

Because planning and project selection decisions take place long before projects are actually constructed, in one sense all outcomes of these decisions are "long-term" outcomes. However, as noted in the matrix above, we distinguish between costs and impacts that occur at the time of construction (which we designate "short-term") and those that occur in the years following construction ("long-term").[1] For example, suppose that a planning decision envisions a new river crossing. A short-term cost would be the expected cost of the bridge construction; a long-term impact would be the public's increased access to both sides of the river, as provided by the completed bridge.

[1] Here, we mean "at the time of construction" broadly. Short-term costs include all costs that would be encompassed in a project's cost estimate, including activities like land purchases that would occur before actual construction work.

Planning

Planning is a key early step in the process of constructing transportation infrastructure. Based on input from various stakeholders, plans identify, gauge the feasibility of, and prioritize future outcomes. Plans set the stage for the project selection process.

Examples of Transportation Plans

System-Wide Plans

20-Year State Highway Investment Plan (2017). Used performance targets to identify overall highway needs and allocated future spending by broad categories over a 20-year period.

Statewide Highway Systems Operation Plan (2012). Identified strategies for improving MnDOT's maintenance work.

Regional/Local Plans

Congestion Management Safety Plan, Phase IV (2018). Identified locations throughout the Twin Cities metropolitan area where relatively small investments could provide large improvements in traffic safety or flow.

Principal Arterial Intersection Conversion Study (2017). Examined 91 major intersections in the Twin Cities metropolitan area to prioritize which should be converted to interchanges with bridges and ramps. (Produced by MnDOT and the Metropolitan Council.)

Alexandria Area 2030 Transportation Study (2011). Outlined potential future transportation improvements in and around the city of Alexandria. (Produced by MnDOT, Douglas County, and the city of Alexandria.)

MnDOT develops or cooperates with others to develop many plans detailing future transportation priorities. Various statewide plans, including the State Highway Investment Plan, set broad priorities for decision making at the system level. At regional and local levels, plans may identify existing or future needs related to factors such as population growth, business development, increasing congestion, safety concerns, or the condition of existing infrastructure. In some studies, planners identify specific projects that would meet those needs. In others, a broader strategy is identified without prioritizing specific projects. Because future funding may not be sufficient to meet all needs, it is important to identify the improvements or strategies that are likely to provide the most value for the amount of money spent.

We did not systematically review MnDOT plans at the state, regional, and local levels for this evaluation. However, we did examine MnDOT's State Highway Investment Plan, which plays an important role in the project selection process, and the Statewide Highway Systems Operation Plan, which outlines maintenance strategies.[2] We also reviewed a few local and regional plans that came to our attention through our review of 30 sample construction projects (which we describe in the next chapter) or through our other research activities.

MnDOT planning studies do not consistently assess the cost-effectiveness of the transportation improvements they examine.

Although we did not assess the full range of MnDOT's planning processes, the plans we did review demonstrated a wide range of analysis. Some plans addressed cost-effectiveness quite directly, while others did not address costs at all. The plans we reviewed always examined long-term public impacts—that is their purpose—but did not necessarily analyze long-term state costs or the short-term public impacts of construction activities. MnDOT's acting planning director told us that the department has no written guidance describing when and how planning studies should include costs or economic analysis.

[2] Minnesota Department of Transportation, *20-Year State Highway Investment Plan 2018-2037* (St. Paul, 2017); and Minnesota Department of Transportation, *Statewide Highway Systems Operation Plan 2012-2015* (St. Paul, 2012).

Planning Studies:
Did MnDOT Analyze These Outcomes?

Short-term state costs **Sometimes**	Short-term public impacts **Sometimes**
Long-term state costs **Sometimes**	Long-term public impacts **Yes**

Some studies we reviewed included very detailed assessments of cost-effectiveness. The State Highway Investment Plan presented a detailed analysis of the funding MnDOT expected to be available for road construction projects over the next 20 years.[3] Because the funding would not be sufficient to meet expected needs, MnDOT predicted how much roads and bridges would deteriorate over time due to delayed maintenance and rehabilitation.

At the regional level, one plan that addressed cost-effectiveness directly was the Metro District's Congestion Management Safety Plan.[4] This plan identified locations throughout the Metro District where MnDOT could make small infrastructure improvements to reduce congestion or increase safety. The plan sought to identify low-cost, high-benefit improvements—for example, adding or lengthening turn lanes—that would fit into the district's budget more easily than large-scale infrastructure projects. The plan evaluated each potential improvement by comparing the cost of the improvement to the expected benefits for the public over time. For each improvement, MnDOT calculated a "project return period," or the amount of time it would take before benefits exceeded costs.

In contrast, some planning studies we reviewed made little effort to assess the cost-effectiveness of the improvements they proposed. For example, MnDOT's Statewide Highway Systems Operation Plan, which described maintenance strategies statewide, raised several concerns about limited funding.[5] However, unlike the State Highway Investment Plan, it did not quantify the likely outcomes that would result from ongoing funding shortages, nor did it prioritize future work based on expected public impacts.

Similarly, a joint Metropolitan Council-Metro District planning study—the Principal Arterial Intersection Conversion Study—did not assess cost-effectiveness.[6] It examined intersections on high-traffic highways for possible conversion to interchanges with bridges and ramps. The study ranked 91 different intersections as having low, medium, or high priority, based mostly on congestion reduction, safety increases, and construction feasibility. The rankings did not incorporate the cost of the conversions; in fact, the study did not offer any estimates of construction costs.

Another local planning study for areas in and around the city of Alexandria (sponsored jointly by MnDOT and local governments) estimated costs for a number of proposed improvements and prioritized them based on their likely impacts on traffic operation.[7]

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[3] Minnesota Department of Transportation, *20-Year State Highway Investment Plan*, Appendix E.

[4] SRF Consulting Group, Inc., and Sambatek, Inc., *Congestion Management Safety Plan | Phase 4: Executive Summary Report for MnDOT Metro District* ([Roseville], 2018), http://www.dot.state.mn.us/metro/programmanagement/pdf/cmsp-phase4-executive-summary.pdf, accessed September 11, 2018.

[5] Minnesota Department of Transportation, *Statewide Highway Systems Operation Plan.*

[6] Bolton & Menk, Inc., and Stonebrooke Engineering, *Principal Arterial Intersection Conversion Study: Final Report* (St. Paul, 2017), https://metrocouncil.org/Transportation/Planning-2/Transit-Plans,-Studies-Reports/Highways-Roads/Principal-Arterial-Intersection-Conversion-Study.aspx, accessed September 18, 2018.

[7] WSB & Associates, Inc., *Alexandria Area 2030 Transportation Study* ([Alexandria], 2011), http://www.dot.state.mn.us/consult/documents/D4alexandriafinalreport.pdf, accessed August 3, 2018.

Despite this prioritization, however, the study did not attempt to quantify the value of each proposed improvement. For example, the highest priority improvement had an estimated cost of $2.1 million, while the fifth ranked improvement was estimated to cost $100,000. Because the value each improvement would provide was not estimated, it was unclear which of these two proposed projects would provide greater benefits per dollar spent.[8]

RECOMMENDATION

MnDOT should develop guidance on the use of cost-effectiveness measures in planning studies.

By their nature, planning studies examine long-term outcomes. Generally, plans that identify specific projects for future consideration should make a case that those projects are more cost-effective than other alternatives. However, plans serve a multitude of purposes, and benefit-cost analyses are probably unnecessary in some planning studies. MnDOT should create guidance on when and how to use cost-effectiveness measures in state, regional, and local transportation plans that MnDOT conducts or sponsors.

Project Selection

As we described in detail in our 2016 evaluation, *MnDOT Highway Project Selection*, MnDOT central and district offices work together to select and schedule most highway construction projects through a standard process.[9] Below, we briefly describe this process and then discuss the extent to which MnDOT assesses financial effectiveness in the computer models that underlie its standard process. We then discuss several alternative processes MnDOT uses to select a small percentage of construction projects, many of which are tied to specific funding sources.

Standard Process

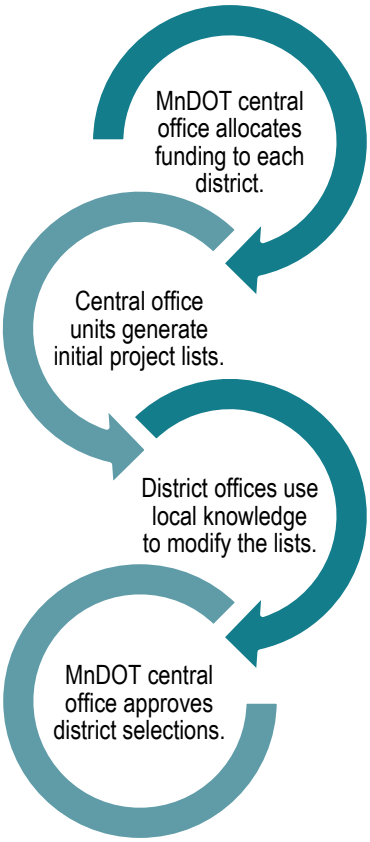
MnDOT's standard project selection process occurs annually through the update of two project listings: the State Transportation Improvement Program (STIP), which lists projects scheduled one to four years into the future; and the Capital Highway Investment Plan (CHIP), which lists projects scheduled five to ten years into the future. Each year, MnDOT begins construction of many projects listed in the previous year's STIP, creating room for MnDOT to move projects into the new STIP from the CHIP, and, in turn, to identify projects for the new CHIP.

The updating process, diagrammed on the next page, begins when MnDOT allocates state road construction funds to districts, which it does based on expected overall revenue and the

[8] This study included potential projects on both trunk highways and county highways. MnDOT is unlikely to initiate projects that do not benefit trunk highways, but does often collaborate with local governments to fund projects with both state and local benefits.

[9] Office of the Legislative Auditor, Program Evaluation Division, *MnDOT Highway Project Selection* (St. Paul, 2016). As we did in that evaluation, for ease of explanation we refer in this section to a "standard" project selection process and several "alternative" processes. MnDOT does not use these terms; the "standard process" encompasses several project selection procedures that follow the same general framework.

size and expected quality of each district's trunk highway network. Once MnDOT's Office of Transportation System Management determines these overall funding amounts, two units in MnDOT's central office—the Materials and Road Research Office and the Bridge Office—develop initial lists of potential highway construction projects for each district for inclusion into the CHIP.[10]



Although the central office lists are an important starting point for project selection, district staff may modify them based on their more nuanced understanding of local conditions. However, the district's modifications should, when combined, produce about the same amount of improvement to the district's highway network as the original central office lists. MnDOT's planning office ultimately approves each district's listing of future projects.

In our 2016 report, we recommended that MnDOT improve the transparency of its standard process by clearly reporting the factors that contribute to project selection decisions. In response to this recommendation, the 2017 Legislature directed MnDOT to adopt and implement a more transparent project selection policy.[11] As a result, MnDOT adopted a new project selection scoring system in November 2018.[12]

For the most part, the new system standardizes criteria that previously existed. Our 2016 evaluation found that districts considered several factors when selecting projects, such as existing pavement and bridge quality, traffic volumes, and the ability to simultaneously address related infrastructure needs. Districts will still rely on these factors, but will now create scores for each factor, leading to a published overall project selection score. The visibility of these project selection scores may affect some project selection decisions, but the overall decision-making framework otherwise remains unchanged.[13]

MnDOT's project selection computer models differ in their consideration of long-term state costs and do not directly address long-term public impacts.

The Materials and Road Research Office and Bridge Office use computer models to develop the pavement and bridge project lists they respectively provide to districts. Both

[10] Nearly all projects scheduled through the standard process primarily *preserve* existing infrastructure, either through pavement projects (proposed by the Materials Office) or bridge projects (proposed by the Bridge Office). Projects that *expand* infrastructure are mostly funded through programs that use alternative selection processes, such as Corridors of Commerce (which we discuss in the next section). However, MnDOT selects some smaller expansion projects through a version of the standard process.

[11] *Laws of Minnesota* 2017, First Special Session, chapter 3, art. 3, sec. 124.

[12] Minnesota Department of Transportation, Project Selection Policy, Policy No. OP016, effective November 30, 2018.

[13] The new system also includes a process for districts to advance projects addressing important needs that are not well represented in the scoring system.

models weigh a number of inputs, including infrastructure asset condition and deterioration, traffic volume, construction history, and MnDOT's budget and performance targets. However, the two models differ in how they analyze long-term state costs, and neither directly analyzes long-term public impacts, as summarized at right.

Standard Project Selection Computer Models: Did MnDOT Analyze These Outcomes?

Short-term state costs **Pavement: Yes** **Bridge: Yes**	Short-term public impacts **Pavement: Yes** **Bridge: Yes**
Long-term state costs **Pavement: Yes** **Bridge: No**	Long-term public impacts **Pavement: No** **Bridge: No**

MnDOT's pavement model analyzes the condition of each segment of road and determines a likely repair project. It then assigns each repair project a cost-effectiveness value, based on estimated construction and long-term maintenance and rehabilitation costs.[14] The cost estimates are based on historical data for past pavement projects. Then, looking across all possible paving projects on all possible highway segments, the computer model selects the combination of projects that produces the best combined cost-effectiveness value for the available funding.

Spotlight: Bridge Repair, Rehabilitation, or Replacement?

MnDOT's guidelines for scoping bridge work are based on the cost of completely replacing a bridge.

If preservation work (repairs that go beyond ordinary maintenance) will address a bridge's needs and will cost less than 30 percent of the full replacement cost, the guidelines suggest preservation techniques are the appropriate repair strategy.

If, however, needed preservation work would exceed 30 percent of the full replacement cost, MnDOT is more likely to plan a rehabilitation project, which could include deck replacement or superstructure strengthening or replacement. Conversely, if a planned rehabilitation project would cost more than 70 percent of the full replacement cost, then the guidelines suggest that MnDOT pursue a full replacement.

The 30 and 70 percent thresholds are guides and not strict criteria. Final decisions are based on the unique circumstances of each bridge. Nonetheless, the thresholds play an important role in justifying what MnDOT will build and how much money it will spend.

The 30 and 70 percent thresholds, however, do not appear to be based on any formal study of how MnDOT can most cost-effectively address bridge deterioration. Senior engineers in the bridge office could not provide any research or analysis that supports their use. MnDOT has used the thresholds for at least two decades.

In contrast, the bridge computer model does not incorporate long-term cost considerations into the development of its project list. The bridge model identifies each bridge requiring repair and selects a repair strategy. However, the model's selection of the appropriate repair strategy does not use long-term maintenance costs as a factor. Rather, the model's selected repair relies on a bridge's current condition, risk factors, and the project's initial cost. Further, as we describe in the box at left, once a bridge project is selected, MnDOT's choice of an appropriate bridge repair strategy is guided by numerical thresholds that supposedly reflect cost-effectiveness assessments but do not appear to have a clear research basis.

Neither the pavement nor bridge model draw upon analyses of long-term public impacts. Most notably, the models do not factor in the impact on the public of future construction or maintenance delays if MnDOT chooses a stopgap fix that will only last a relatively short time.

Both models incorporate public impacts only indirectly. Both use traffic volume as a factor; as a result, projects affecting greater numbers of travelers tend to receive preference in the computer-generated project lists. Further, the

[14] The "cost-effectiveness value" is based on how much smooth highway surface can be achieved from a given amount of funds. The Materials and Road Research Office does not attempt to estimate how much benefit travelers gain from driving on smooth roads instead of rough roads.

bridge model uses the length of a potential detour as a rough measure of the disruption that would occur if delaying work meant a bridge deteriorated to the point of closure.

Although MnDOT's computer project selection models do not include all the components of cost-effectiveness we identify in our matrix, it is important to emphasize that the computer-generated lists are not the final project selections. MnDOT's district offices often modify the central office lists, and may take into account long-term costs and benefits when doing so. For example, districts might make a project more cost-effective by combining it with a second project or adding roadside infrastructure repairs.

However, as we described in our 2016 evaluation, the process of project selection at the district level is not transparent, making it difficult to assess whether districts' choices consistently increase cost-effectiveness. MnDOT's new project selection scoring system, which is intended to increase transparency, had not yet been implemented at the time we prepared this report. Thus, it is unclear whether the new scoring system will affect how districts modify the computer-generated lists to make their final project selections.

A new computer tool that MnDOT is developing for selecting pavement preservation projects may improve its measurement of long-term costs and public impacts.

MnDOT's Materials and Road Research Office is currently developing an updated computer model for districts to use during the project selection process.

The new tool, scheduled for implementation in the summer of 2019, will use new performance indicators that reflect long-term costs and public impacts. For example, MnDOT will begin measuring the amount of overall traffic volumes on rough roads compared to smooth roads. MnDOT is also developing an asset sustainability ratio, which will estimate how the highway network's overall pavement health would change after various combinations of preservation activities. Districts will be able to use the new tool to analyze how the indicators would change under different project selection scenarios.

The director of the Materials and Road Research Office told us that the indicators it is introducing in the new computer model are experimental. Some may become important factors in district decision-making, while others may be dropped eventually as redundant or unhelpful. As a result, it is unclear exactly how implementation of the new computer tool will affect MnDOT's selection of pavement projects.

RECOMMENDATION

MnDOT should consider formally including long-term public impacts in the computer models that facilitate its project selection processes.

The consequences for the public of preservation projects are different from those projects that build new infrastructure. Ideally, new infrastructure provides new public benefits. But for preservation projects, the most important public impacts occur when the work is *not* completed. Pavements may deteriorate to the point they become uncomfortable to drive and require infeasible amounts of ongoing maintenance. Bridges that are not rehabilitated or replaced may eventually require more frequent inspections, load restrictions, or even closures. Analyzing the public impacts of these potential reductions in service clarifies the importance of the preservation work that is needed.

Further, the traveling public experiences different long-term impacts based on the lifespan of the preservation work that MnDOT completes. According to MnDOT pavement specialists, the department can keep a road meeting its performance targets by simply adding layer after layer of thin asphalt every few years. However, there is a significant difference in public impact between repeated construction delays that recur every few years and one thorough reconstruction that installs pavement lasting for decades.

MnDOT's computer models for the selection of pavement and bridge preservation projects do not directly analyze public impacts, though some factors (such as traffic volume) address them indirectly. As MnDOT continues to adjust these models over time, we encourage the department to look for ways to more directly incorporate long-term public impacts. As we discuss above, MnDOT is currently reconfiguring its computer model for pavement projects in ways that may address this recommendation.

Alternative Processes

MnDOT runs nearly a dozen separate small construction programs for which projects do not go through the standard project selection process. Some of the programs using these alternative processes, such as Corridors of Commerce, are codified in state law.[15] Others exist to distribute federal funding dedicated to certain purposes, such as the Highway Safety Improvement Program. Some simply serve as a way for MnDOT to fund projects that do not fit easily into the standard process. These alternative selection processes serve a number of purposes, ranging from promoting job creation or retention to repairing rest areas and historic properties. Many, but not all, of the programs use a competitive selection process in which project proposers compete against one another for a limited amount of available funding.

MnDOT's alternative project selection processes vary in their use of cost-effectiveness criteria.

Some alternative processes include criteria that measure long-term costs and public impacts, while others do not. Some processes that do include assessments of long-term impacts focus primarily on impacts related to the purpose of the funding program. For example, the selection process for the Highway Safety Improvement Program includes an assessment of long-term safety impacts, but does not assess any benefits gained from reducing traffic congestion. MnDOT incorporates long-term maintenance and infrastructure replacement costs into only one of these alternative selection processes, the Intelligent Transportation Systems Program. The box on the next page provides an overview of the differences among programs.

Five of MnDOT's 11 alternative programs use benefit-cost analyses, among other criteria, to compare candidate projects and ultimately make final selections.[16] For example, applicants to the Transportation Economic Development program must submit sufficient data for MnDOT to calculate benefit-cost ratios for their proposed projects. Similarly, the Corridors of Commerce program also uses a form of benefit-cost analysis, ranking proposed projects based on construction costs and reductions in traffic incidents and commute

[15] See, for example, *Minnesota Statutes* 2018, 161.088 and 174.12.

[16] As of November 2018, MnDOT was revising or considering revising criteria for the Highway Freight Program, the Highway Safety Improvement Program, and the Local Partnership Program.

Alternative Project Selection Processes

Program	Incorporates long-term costs?	Incorporates public impacts?
Corridors of Commerce		✓
Highway Freight		✓
Highway Safety Improvement		✓
Historic Roadside Properties		
Intelligent Transportation Systems	✓	
Local Partnership		✓
Noise Barriers (stand-alone)		✓
Railway-Highway Crossings		✓
Safety Rest Areas		
Transportation and Economic Development		✓
Weigh Stations		

times.[17] A third example, the Stand Alone Noise Barrier Program, selects eligible projects based on the number of residential units that receive noise reductions compared to the cost of a noise barrier.[18]

Some of the programs that do incorporate cost-effectiveness in their project selection criteria are required by law to do so. For example, the Legislature requires that all projects under consideration for Corridors of Commerce funding be evaluated using a project's "return on investment."[19] Similarly, MnDOT must evaluate the extent to which candidate projects for the Transportation Economic Development Program provide measurable economic benefit.[20]

Three of MnDOT's programs for selecting alternative projects—the Historic Roadside Properties Program, the Safety Rest Area Program, and the Weigh Station Capital Improvement Program—do not directly incorporate any financial effectiveness criteria. For these programs, cost-effectiveness would likely be awkward to measure using traditional methods. For example, the benefits gained from historic preservation are intangible and probably unquantifiable. Similarly, it is difficult to compute how much benefit the public gains when MnDOT maintains or improves a highway rest area.

It may be possible for MnDOT to add additional cost-effectiveness criteria to some alternative project selection processes that do not currently include them. We make no formal recommendations at this time, in part because we did not examine in detail the individual programs involved. However, we broadly encourage MnDOT to explore whether it would be feasible to add assessments of long-term state costs to some of these selection processes.

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[17] The construction costs used in the benefit-cost calculation are the costs paid by the Corridors of Commerce program only. Thus, a local government could potentially improve the ranking of a project it proposes for the program by offering to fund a portion of the construction costs itself.

[18] The noise barriers are "stand-alone" because the program funds barriers that are not associated with a roadway project. In Minnesota, most noise barrier construction is associated with larger roadway construction projects, and thus is funded through project budgets. See Office of the Legislative Auditor, Program Evaluation Division, *MnDOT Noise Barriers* (St. Paul, 2013).

[19] *Minnesota Statutes* 2018, 161.088, subd. 5(c).

[20] *Minnesota Statutes* 2018, 174.12, subd. 5(1). MnDOT shares with the Department of Employment and Economic Development the responsibility for evaluating proposed Transportation Economic Development projects.


THE GREAT SEAL OF THE STATE OF MINNESOTA
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Chapter 4: Project Scoping and Design

Once MnDOT has decided which construction projects it will build, its engineers carry out a series of project-level processes to move those projects to completion. There are dozens of processes to manage, such as identifying and purchasing any land needed for the project, identifying and addressing environmental concerns, designing the construction and choosing among possible materials or geometric layouts, determining what form of contracting will be used to bid out the project, and overseeing the actual construction itself.

In this chapter, we focus on several decision points that occur during these processes. For each decision point, we examine whether and how MnDOT assesses the financial effectiveness of its decisions. As in Chapter 3, our guiding framework relies on the two dimensions we discussed at the end of Chapter 2: does MnDOT assess short-term and long-term outcomes, and does it assess outcomes for both MnDOT and the general public? For each decision, we return to the two-by-two matrix we introduced in Chapter 2. To optimize financial effectiveness, MnDOT should examine outcomes in all four quadrants of the matrix. To the extent feasible, such examinations should be analytic and evidence-based, and not drawn solely from informal professional judgments.

Outcomes MnDOT Should Analyze to Address Financial Effectiveness

Short-term state costs How a decision will affect a project's construction costs	**Short-term public impacts** How a decision will affect the public during construction
Long-term state costs How a decision will affect future costs (due to maintenance or reconstruction needs, etc.)	**Long-term public impacts** How a decision will affect the public in the future (by altering travel times, safety, the environment, etc.)

Our discussion throughout this chapter is informed by our examination of documents from 30 large road construction projects. We chose these projects from the "major" projects that were contracted out in calendar years 2015, 2016, or 2017—by law, major projects are projects outside MnDOT's Metro District expected to cost at least $5 million or Metro District projects expected to cost at least $15 million.[1] We did not randomly select the projects, but instead chose as diverse a group of projects as possible.[2] Because our sample was illustrative, rather than representative, we supplemented our document reviews with interviews of MnDOT staff to confirm that patterns we observed reflected departmental practices.

Scoping

Scoping is the process of deciding what elements a project will include. During scoping, MnDOT district staff determine the type of work that will be done, identify risks and their potential impacts, estimate the costs of construction and land acquisition, line up funding sources, and decide whether to add additional components to the project beyond its primary

[1] *Minnesota Statutes* 2018, 174.56. As shown on the map in Chapter 1, MnDOT's Metro District covers Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, and Washington counties.

[2] We excluded projects involving a state or national border crossing.

purpose. Most scoping decisions take place after MnDOT has tentatively decided to construct a project, but before it makes a definite public commitment.[3]

MnDOT does not ordinarily state the basis for its scoping decisions in its primary scoping documents.

Scoping involves a series of choices. Almost any project can be built in several different ways, all of which meet the project's primary purpose but differ in other respects. A repaving project, for example, might or might not include additional work to improve shoulders and drainage, depending on need and available funding. A bridge project might replace the bridge deck while leaving bridge supports in place, or might replace the entire bridge.

However, the MnDOT scoping documents we reviewed generally provided only the final project scope after decisions were made by MnDOT project staff. Although the documents sometimes listed alternatives that were considered but rejected, there was often little or no discussion of why the final alternative was preferred over other project choices. A MnDOT administrator confirmed that MnDOT staff frequently do not formally document comparisons of project alternatives, although other less formal documentation may sometimes exist (such as e-mails, meeting notes, or memos).[4]

Due to the lack of documentation, we were unable to evaluate how MnDOT takes financial effectiveness into account for many scoping decisions. However, one key scoping process does require written justification for scoping decisions. We examined this process more closely in order to gain a window into how MnDOT makes scoping decisions.

Environmental Reviews

Federal and state laws require that MnDOT develop an *environmental document* for many projects.[5] Environmental documents examine the potential ecological, social, economic, and cultural impacts of government actions. Different projects require different documents (described briefly in the box below), depending on whether they trigger the requirements of various federal and state regulations. Generally, MnDOT is likely to create more extensive environmental documents for projects that build roadway on a new location and thus increase the potential for significant environmental effects. Projects that solely rehabilitate or reconstruct existing infrastructure often require less extensive environmental documentation.

[3] The earliest scoping work actually occurs before the project selection process; at a minimum, MnDOT staff must roughly outline a project and estimate its overall cost before it can be selected for a future construction year.

[4] There are some decision-making processes specific to certain projects where comparisons of alternatives are explicitly documented. In addition to the environmental reviews we discuss below, some permitting agencies (such as the Minnesota Pollution Control Agency or the U.S. Army Corps of Engineers) require that MnDOT demonstrate its preferred alternative addresses the project's purpose while minimizing environmental impacts. For projects involving an intersection, MnDOT develops a document that evaluates different design alternatives (for example, stoplights, roundabouts, different turn lane configurations, etc.) for that specific location within the project.

[5] 23 *CFR*, sec. 771 (2018); The National Environmental Policy Act of 1969, 42 *U.S. Code*, secs. 4321 to 4370m-12 (2017); *Minnesota Rules*, 4410.4300, subps. 1 and 22, published electronically September 5, 2013; *Minnesota Rules*, 4410.4400, subps. 1 and 16, published electronically November 30, 2009; and *Minnesota Statutes* 2018, 116D.04.

For some projects, MnDOT must explicitly state the reasons for its project scoping decisions in environmental documents.

For projects that require more extensive environmental documents, MnDOT must develop and compare alternative approaches to meeting the project's goals.[6] Alternatives for a highway project could include, for example, different highway interchange configurations or different numbers of lanes. One of the alternatives MnDOT considers must always be the *no-build alternative*—that is, MnDOT must address what would happen if it does not construct the project.[7]

After evaluating the alternatives, MnDOT selects the *preferred alternative*, which defines the project that will eventually be constructed. Although the selection of a preferred alternative must take into account the findings of the environmental review, it need not be based solely on environmental factors—issues like cost, durability, and safety may be crucial factors.

The preferred alternative must emerge from an objective evaluation of alternatives. MnDOT cannot start the environmental review process with an alternative already chosen. Thus, the environmental review process can represent a key decision point in determining what will actually be built.

Environmental Documents

Environmental Impact Statement (EIS). Most extensive environmental review. Required for federally funded or approved projects that significantly affect the environment (may also be required under Minnesota state law). Must thoroughly analyze project alternatives.

Environmental Assessment (EA). More limited environmental review. Used to determine if an EIS is necessary. Required for federally funded or approved projects whose potential environmental effects are unclear or unknown. Usually compares project alternatives.

Categorical Exclusion. Environmental review demonstrating a federally funded or approved project has no significant environmental effects. Depending on project complexity, may range from very concise to very detailed. More detailed categorical exclusions often compare project alternatives.

Environmental Assessment Worksheet (EAW). State environmental review required of projects meeting certain thresholds in state law. May be folded into an EA if the project also has federal involvement. Does not compare project alternatives (unless combined with an EA).

MnDOT's evaluations of project alternatives in environmental documents inconsistently analyze state costs and public impacts.

In over one-third of the 30 projects that we examined, MnDOT included a discussion comparing project alternatives within environmental documents. Typically, a primary criterion for evaluating alternatives was whether the alternative would sufficiently address the stated purpose of the project. MnDOT rejected alternatives that did not meet the project's stated purpose (these often included the no-build alternatives).

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[6] Environmental Impact Statements (see box) must include an evaluation of alternatives under federal law. 23 *CFR*, secs. 771.123(c) and 771.125(a)(1) (2018). Federal Highway Administration (FHWA) regional offices may also require that Environmental Assessments and Categorical Exclusions include comparisons of alternatives.

[7] A no-build alternative does not mean that no action at all would occur. For a repaving project, for example, MnDOT's evaluation of the no-build alternative might predict the department would do more maintenance work as the road surface deteriorates.

However, when multiple alternatives would address the project purpose, MnDOT's documented basis for deciding among alternatives varied from project to project. In some instances, the most important criteria appeared to be short-term construction costs and traffic impacts. In others, long-term safety considerations played an important role. Some decisions were based on limiting environmental impacts, such as damage to wetlands.

Environmental Reviews: Does MnDOT Analyze These Outcomes?

Short-term state costs **Sometimes**	Short-term public impacts **Sometimes**
Long-term state costs **Sometimes**	Long-term public impacts **Sometimes**

As we illustrate in the matrix above, MnDOT's examinations of the state costs and public impacts of project alternatives varied widely in the environmental documents we examined. At least one document did not discuss the costs of the alternatives considered at all. Others paid significant attention to immediate construction costs, but did not discuss the different long-term maintenance costs of alternatives. One document did not address long-term public impacts such as traffic congestion or safety; others contained detailed discussions that directly led to the selection of the preferred alternative. In an example highlighted in the box at left, an appendix to the environmental document contained an analysis of long-term costs, but the document's discussion of alternatives made no mention of the analysis.

Spotlight: Broadway Bridge, St. Peter (Highway 99)

MnDOT needed to address deterioration of this historic 1931 bridge over the Minnesota River. The department's environmental document examined four alternatives: (1) minor rehabilitation; (2) major rehabilitation, including strengthening the bridge to support heavier loads; (3) major rehabilitation plus lengthening the bridge to reduce flooding risk; and (4) full replacement and relocation of the historic bridge nearby to become a pedestrian bridge.

All of the alternatives had problems. The first did not address the bridge's inadequacy to support modern heavy truck traffic. The second addressed that concern, but would not address a state law requiring MnDOT to repair or replace "fracture critical" bridges. The third and fourth alternatives were opposed by the State Historical Preservation Office due to the historic nature of the bridge. The Federal Highway Administration also opposed the fourth alternative on historical preservation grounds.

MnDOT chose the second alternative. The document noted that the department might need to inform the Legislature of the exception to state law. MnDOT's discussion of alternatives did not mention either short-term or long-term costs, even though MnDOT had conducted an analysis of the long-term costs of the first three alternatives.

In some instances MnDOT said its decisions were based on financial effectiveness considerations, but there was no explanation of how MnDOT had defined or measured them. In one environmental document for a project on Interstate 35 that included three bridge replacements, for example, MnDOT summarily rejected redecking the bridges instead of replacing them because redecking was not "cost-effective." The document offered no cost figures, no explanation of how it defined cost-effectiveness, and did not explain whether MnDOT's assessment of cost-effectiveness had considered public benefits in addition to state costs.

In another example, MnDOT's examination of alternatives clearly identified the differing costs for alternatives to an Interstate 494 project, but the difference in benefits was not quantified. MnDOT's discussion of the preferred alternative noted that it was $30 million more expensive than a rejected alternative, and even acknowledged that it did not fit a "low cost/high benefit approach to project development." The discussion then went on to describe some of the advantages of the preferred alternative, but did not demonstrate that those advantages were worth an additional $30 million investment.

In another instance of vaguely defined benefits, MnDOT rejected a short-term fix for an Interstate 90 project because it "would lower drivers' expectations as to how reliable the roadway is to travel." MnDOT presented no evidence in the document that it had taken any steps to assess driver expectations, determine why they might change, or evaluate the long-term consequences of changed expectations.

Benefit-Cost Analyses

MnDOT occasionally conducts project-level benefit-cost analyses as part of the scoping process. As we explained in Chapter 2, benefit-cost analyses are key assessments of financial effectiveness in transportation decision making, though we cautioned that such analyses have important limitations. A benefit-cost analysis assigns monetary values to all outcomes of a government action, then tabulates all of the costs and benefits expected. As shown in the matrix at right, MnDOT's benefit-cost analyses address all dimensions of cost-effectiveness except the impacts of construction on the public. Such negative impacts are usually small compared to the years of benefits gained, and it is not unusual to omit them from benefit-cost studies.

Benefit-Cost Analyses: Does MnDOT Analyze These Outcomes?

Short-term state costs **Yes**	Short-term public impacts **No**
Long-term state costs **Yes**	Long-term public impacts **Yes**

Under MnDOT's standard benefit-cost methodology (also described in Chapter 2), each analysis calculates an estimated benefit-cost ratio. A ratio greater than 1.0 indicates that expected total benefits are greater than the expected total costs. Conversely, a ratio less than 1.0 indicates that total benefits are estimated to be less than costs.

MnDOT has a policy requiring it to conduct project-level benefit-cost analyses, but it applies to very few projects.

MnDOT instituted a "Cost-Effectiveness Policy" in 2003.[8] The policy requires that MnDOT conduct a benefit-cost analysis for every project requiring an Environmental Impact Statement, an Environmental Assessment, or an Environmental Assessment Worksheet.

However, very few projects require one of the three environmental documents that trigger the cost-effectiveness policy. According to MnDOT, 1,228 projects were contracted out to construction firms in calendar years 2013-2017. Only about 20 (2 percent) triggered the cost-effectiveness policy.[9]

Further, projects that do trigger the cost-effectiveness policy are not necessarily among the largest MnDOT projects. Of the ten most expensive highway projects MnDOT let for bids in 2015, 2016, or 2017, only two met the policy's criteria for a benefit-cost analysis. MnDOT's policy did not require it to conduct benefit-cost analyses for the other eight,

[8] Minnesota Department of Transportation, "Cost-Effectiveness Policy," updated November 9, 2018, http://dotapp7.dot.state.mn.us/eDIGS_guest/DMResultSet/download?docId=608945, accessed January 17, 2019.

[9] In providing us these data, MnDOT had some difficulties matching environmental documents to projects; 20 may be a slight undercount.

including a $115 million project on Interstate 494 between Maple Grove and Minnetonka and a $61 million bridge replacement on Highway 169 in Hopkins and Edina.[10]

MnDOT's benefit-cost methodology is structured so that projects that add new roadway infrastructure will almost always appear justified.

Under MnDOT's cost-effectiveness policy, if a project's estimated benefit-cost ratio is 1.0 or greater, the project can move forward. If the ratio is less than 1.0—that is, estimated total benefits are less than the estimated total costs—then MnDOT reexamines the project to see if it can be rescoped or reconfigured so that benefits will exceed costs. A project may also proceed despite not meeting the 1.0 threshold if it is an essential part of some larger project that does meet the threshold.[11]

As stated above, MnDOT requires that projects triggering the cost-effectiveness policy have a benefit-cost ratio of at least 1.0 to move forward, except in special circumstances. However, in practice, this threshold is usually easy to meet. All but one of the benefit-cost analyses we reviewed for projects meeting the threshold had benefit-cost ratios greater than 1.0.[12] Aside from the lone exception, in instances where benefit-cost studies analyzed several possible alternatives for the same project, all of the different possibilities had benefit-cost ratios higher than 1.0. MnDOT staff told us that it has been historically rare for a project analyzed under the policy to have a ratio lower than 1.0.

The benefit-cost ratios have almost always been greater than 1.0—that is, benefits almost always exceeded costs—because of structural characteristics of the benefit-cost analysis itself. As we discussed in Chapter 2, benefit-cost analyses place a value on travel time savings, or the amount of time travelers gain when traffic moves faster. Although this value is only pennies per traveler per minute saved, it adds up to large amounts when calculating total benefits for all travelers over a long period of time. As we explained above, projects that require more extensive environmental reviews—and thus trigger MnDOT's cost-effectiveness policy—tend to be those that add roadway infrastructure. Most projects that involve such infrastructure additions speed the flow of traffic, so projects that trigger the cost-effectiveness policy will usually have substantial travel time savings.

For example, using MnDOT's July 2018 default benefit-cost parameters, a project that would speed up traffic by two minutes per weekday trip on a road averaging 5,000 travelers a day would create an estimated benefit of $14.5 million over a 20-year period. Thus, the travel time savings alone would justify a project costing any amount less than $14.5 million before any consideration of other benefits, such as increased safety. For a busy

[10] For at least two of these eight projects where MnDOT did not require a benefit-cost analysis, the department had previously conducted benefit-cost analyses of larger proposed projects that included the smaller projects eventually constructed. MnDOT did not update these studies to analyze the benefits and costs of the actual projects that were built.

[11] If benefits remain less than costs despite rescoping, a project may still proceed if it provides unusual social, economic, or community benefits that cannot be realized in a more cost-effective way. For example, MnDOT might build such a project if it provided access to an important cultural or scenic location. Such projects are rare, and senior MnDOT management must approve any project subject to the cost-effectiveness policy that moves forward on this basis.

[12] One project built through the Corridors of Commerce program added passing lanes in six locations along a 140-mile stretch of Highway 23. The benefit-cost analysis separately analyzed 13 candidate locations for the addition of passing lanes. The average benefit-cost ratio per individual location was 0.67. MnDOT did not assess combinations of locations; it is possible that the combined benefits of multiple locations were greater than the benefit gained from each location considered separately.

Spotlight: Highway 371 Expansion, Pequot Lakes

MnDOT first prepared a benefit-cost analysis for this two-lane to four-lane expansion in 2003. The preferred alternative in the original EIS, finalized in 2005, was to expand the existing highway through the city of Pequot Lakes. This option had the highest benefit-cost ratio of the studied alternatives, though MnDOT also cited many other factors in its decision.

However, the city later asked MnDOT to build a bypass instead. MnDOT agreed, though it said costs would prevent it from building an interchange with a bridge and ramps east of town where Highway 371 would cross County Highway 11. MnDOT prepared an updated benefit-cost analysis in 2008. The new configuration had a benefit-cost ratio of 3.5, slightly lower than the updated ratio for the through-town alternative (3.8).

In 2015, when MnDOT was ready to move forward with construction, the project had changed again. The starting and ending points of the project had shifted, making it shorter than the project as initially analyzed. Also, MnDOT decided to build the interchange at County Highway 11 after all, substantially increasing the cost of that part of the project. MnDOT did not update its benefit-cost analysis, so there is no estimate of the benefit-cost ratio for the project as finally built.

metropolitan-area highway averaging 75,000 travelers a day, even an improvement that speeds up travel times by just 30 seconds per trip would create an estimated benefit of over $54 million in travel time savings over a 20-year period.[13]

Even when MnDOT does conduct project benefit-cost analyses, its decision makers may not make use of the evaluations.

All alternatives with benefit-cost ratios greater than 1.0 satisfy MnDOT's cost-effectiveness policy. However, the policy does not require project managers to consider which alternatives have higher estimated benefit-cost ratios when making final decisions about project configurations.

Of the 30 projects that we reviewed closely, five had benefit-cost analyses, most of which calculated a benefit-cost ratio for each project alternative.[14] In all but one of the five instances, the benefit-cost analysis was incorporated into the environmental document. Even so, for two of the projects, MnDOT's explanation for why it chose the preferred alternative in the final environmental document did not mention the benefit-cost analysis. For one project (summarized in the box at left), an earlier benefit-cost analysis was cited as one of the reasons to choose the preferred project configuration—but the project was later changed and the final configuration was never analyzed.

RECOMMENDATION

MnDOT should reexamine its cost-effectiveness policy.

In principle, we endorse the concept of a policy that requires benefit-cost analyses for major projects. However, MnDOT's current use of project-level benefit-cost analyses is lacking. Many large MnDOT projects do not fall within the cost-effectiveness policy. For those that do, MnDOT's current cost-effectiveness policy sets a minimum threshold that is easy for projects to meet. Further, MnDOT's explanations of its scoping decisions sometimes do not even mention the results of the benefit-cost analyses, suggesting that the results played little meaningful role in project decision making. Performing a benefit-cost analysis sometimes appears to be more of a "box to be checked" than a process that produces useful evidence for decision makers.

[13] In actuality, the benefits in this paragraph are understated, since they consider weekday travel and passenger vehicles only. Adding in the time savings gained for weekend travel and a proportional number of truck trips would increase the total benefits.

[14] This count includes only projects where the benefit-cost analysis actually assessed the final project configuration.

MnDOT should develop a stronger rationale for when and how benefit-cost analyses should be used at the project level. Given the structural characteristics that make it likely that benefit-cost ratios for expansion projects will exceed 1.0, we suggest deemphasizing that threshold. Instead, MnDOT should pay closer attention to the comparisons of benefit-cost ratios across project alternatives.

We note that MnDOT's new project selection scoring system, which we discussed in Chapter 3, requires a benefit-cost analysis for projects that expand MnDOT's existing roadway infrastructure in the Twin Cities metropolitan area.[15] The standard scoring system gives more points for higher benefit-cost ratios, making projects with higher ratios more likely to be selected. Although this is an improvement over a simple threshold of 1.0, it is not clear how the new policy will work in practice. As we also noted in Chapter 3, MnDOT currently funds many expansion projects through alternative project selection processes that have their own scoring systems. Further, the project selection process does not address the different scoping alternatives that MnDOT staff may consider after MnDOT decides to advance a project through the selection process.

RECOMMENDATION

MnDOT should consider developing better documentation of the financial elements that inform project scoping decisions.

As we described above, standard project scoping documents rarely provide comparisons of the different alternatives examined by MnDOT staff when scoping projects. But even when such comparisons are explicit, as in the environmental review process, MnDOT does not consistently document the alternatives' costs and benefits.

However, the lack of documentation does not mean that project managers and other decision makers ignore state costs and public impacts. In fact, district administrators told us that project costs and outcomes for the public are crucial considerations in the scoping process. But without documentation of what financial alternatives are considered and what decisions are made, assessing financial effectiveness in the scoping process is impossible. The documentation that is available—in the form of environmental documents—suggests that financial effectiveness considerations vary substantially from project to project.

MnDOT should consider adjusting existing documentation requirements for scoping so that project teams demonstrate they have assessed the long-term state costs and public impacts of project alternatives. We did not examine the full extent of documentation already required in the project development process, so it is difficult to assess the extent to which such changes would be burdensome for MnDOT staff. However, the lack of record keeping in current practice makes it difficult to evaluate MnDOT's performance, and it is hard to envision how MnDOT could evaluate strategies to improve financial effectiveness in the scoping process without such documentation.

Design

Design is the process of preparing for the construction of the project defined during the scoping process. In addition to the preparation of site surveys, geotechnical evaluations,

[15] The benefit-cost analysis is required for projects intended to reduce traffic congestion. The policy does not require benefit-cost analyses for similar projects in greater Minnesota.

permit applications, and traffic management plans, MnDOT staff specify exactly how the project will be built and what materials will be needed. Design work concludes with the creation of detailed plans and specifications ensuring that when contractors bid on the work, their bids are comparable.[16]

Performance-Based Practical Design

As we discussed in Chapter 2, state law has required MnDOT to report on the money it has saved through implementing "efficiencies."[17] In its reports to the Legislature, MnDOT has cited "Performance-Based Practical Design" as the largest source of money savings. Below, we describe this design approach and examine its use by the department.[18]

MnDOT, in line with national trends, has begun changing its design practices to reduce project costs.

"Performance-based practical design" is a philosophy centered on "right-sizing" projects—building the appropriate amount of infrastructure to meet a stated need, and no more. Pioneered by the Missouri Department of Transportation in the 2000s, the approach has been adopted in various forms by several states and is embraced by the Federal Highway Administration (FHWA). There are several key principles associated with the philosophy, but there is no single definition that has gained widespread acceptance. One study summarized "practical design" as follows:

> [States using the approach] are not using the same label; however, they have a common goal—developing individual projects cost-effectively to meet only the project's purpose and need and applying cost savings for additional projects, thereby optimizing their budgets statewide.[19]

In general, performance-based design principles focus on spending the appropriate amount on construction in order to provide the desired long-term benefits for the public. As we highlight in the matrix at right, MnDOT's guidance document on performance-based practical design barely discusses long-term maintenance or

Performance-Based Practical Design: Does MnDOT Analyze These Outcomes?

Short-term state costs **Yes**	Short-term public impacts **No**
Long-term state costs **No**	Long-term public impacts **Yes**

[16] As we discuss in the last section of this chapter, for some projects MnDOT uses alternative contracting procedures in which the contractors building the improvement do much of the design work.

[17] *Minnesota Statutes* 2018, 174.56.

[18] This section of the chapter is primarily based on MnDOT guidance documents and interviews with MnDOT staff. We did not have the technical expertise to assess whether detailed project design plans met MnDOT's new criteria.

[19] Hugh W. McGee, Sr., *Practical Highway Design Solutions: A Synthesis of Highway Practice*, National Cooperative Highway Research Program Synthesis 443 (Washington, DC: Transportation Research Board, 2013), 33.

infrastructure replacement costs, nor does it address construction delays or other short-term public impacts.

According to the MnDOT Design Flexibility Engineer, the department has been moving toward performance-based practical design approaches since at least 2009, when it began promoting "flexible" road designs. However, MnDOT did not create a formal performance-based practical design policy until 2017; the department issued a technical memorandum describing the department's implementation of the policy in early 2018.

Performance-based practical design overturns the longstanding practice of designing highway projects so that the resulting roadway meets predetermined design standards. Instead, the designer is asked to evaluate what components are really needed. For example, when reconstructing an older highway, design standards may call for an eight-foot shoulder width. However, if the existing four-foot shoulder has performed adequately, the designer is encouraged to seek an exception to the standards and rebuild with the same shoulder width—creating savings in pavement and land acquisition costs.[20]

Further, the philosophy also promotes the reassessment of traditional design practices by analyzing actual performance data. For example, highway engineers have long sought to build highways to the highest "design speed" feasible, even if actual speed limits were much lower. Transportation professionals believed that a highway designed to accommodate vehicle speeds of 75 miles per hour would be inherently safer than a highway designed to accommodate speeds of 55 miles per hour, even if both roads had a 55-mile-per-hour speed limit. But this belief has not been supported by research. MnDOT's guidance document for performance-based practical design notes:

> An analysis of crash data throughout Minnesota finds no statistically significant correlation between design speed and crash rate on rural two-lane highways. Notably, there are anecdotal examples of *increasing* crash frequency resulting from highway reconstruction that increased the design speed, suggesting the consequence of excessive speeds or speed differentials.[21] [Emphasis in original.]

It is unclear how MnDOT could measure the implementation of cost-effective design approaches.

The extent to which MnDOT follows performance-based practical design principles is difficult to assess. Because the philosophy is based on creating the "right-sized" project for each individual context, one cannot, for example, simplistically count projects built with four-foot shoulders as examples of practical design and projects built with wider shoulders as missed opportunities. Each design decision must be evaluated in context.

MnDOT's Design Flexibility Engineer told us that his office experimented with conducting design "audits," in which design specialists reviewed a sample of past projects to see whether performance-based practical design principles had been followed. However, the audits proved to be time-consuming and did not result in any cost savings—by the time the

[20] A MnDOT design specialist told us that most suggestions based on performance-based practical design principles reduce project costs. However, because designers are encouraged to design to a project's specific needs, performance-based practical design principles may sometimes lead to more expensive configurations.

[21] Minnesota Department of Transportation, *Performance-Based Practical Design; Process and Design Guidance* (St. Paul, 2018), 17.

audits were started, it was too late to make changes—so the effort was dropped. Even if the audits had been more fruitful, we note that they were essentially subjective; they basically consisted of one engineer assessing another's work.

Because of these measurement difficulties, it is unclear how to interpret the cost-saving "efficiencies" MnDOT has reported to the Legislature as a result of implementing performance-based practical design. As we observed in Chapter 2, only projects with examples of money-saving design changes have been included. However, MnDOT design specialists have unsuccessfully sought such changes in other projects.

MnDOT has not developed processes to ensure that project decision makers consistently use cost-effective design approaches.

MnDOT leadership has expressed its commitment to the new design principles, and its new policy requires that planners, project managers, designers, traffic engineers, and district leadership teams follow them. However, MnDOT has not created a process for ensuring that these changes occur. MnDOT senior design specialists told us that some engineering staff within the department have been reluctant to adopt the new philosophy.[22] Under current decision-making processes, design decisions are made at the district level.[23] Central office design specialists report that they must often lobby for their recommendations to be followed, and suggestions for more cost-effective designs are often rejected by district-level staff.

Further, Minnesota's requirements for municipal consent complicate MnDOT decision making around design. Under state law, MnDOT must submit final design layouts to any municipality in which a project is planned if the project will alter access, affect highway traffic capacity, or require the purchase of land.[24] If the municipality objects to the project as designed, delays can occur while MnDOT and the municipality negotiate a mutually agreeable resolution.[25] Thus, a MnDOT district may reject cost-effective design recommendations due to fears of local objections, even if district-level designers agree with the recommendations.

RECOMMENDATION

MnDOT should develop additional procedures to ensure its staff adhere to the performance-based practical design policy.

In our view, MnDOT's shift toward performance-based practical design holds considerable promise from a financial effectiveness perspective. Because performance-based practical design principles apply to all facets of project design, every project could benefit from their implementation. Even small changes could lead to large cost savings if multiplied across hundreds of projects.

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[22] A less common problem has been that a few designers have been too enthusiastic to cut costs, proposing less expensive designs that would inappropriately reduce performance.

[23] Central office design units may occasionally require changes to a project if they believe a design is actually unsafe.

[24] *Minnesota Statutes* 2018, 161.163, subd. 1, and 161.164.

[25] The municipal consent law provides for an appeals process if needed, but MnDOT administrators told us disputes almost never go to an appeal. See *Minnesota Statutes* 2018, 161.164-161.166.

MnDOT should be using more than persuasion to ensure that the new design principles are followed, and it should be evaluating the success of the policy's implementation. However, because of the amorphous nature of this design approach, it is difficult to envision a performance measure that could be identified and tracked. Instead, we suggest MnDOT create a process that project teams must follow to demonstrate they have considered practical design criteria. MnDOT could then evaluate implementation by assessing whether project teams follow the required process. MnDOT is already taking some steps in this direction; it is currently revising the department's road design manual to incorporate performance-based practical design principles.

Life-Cycle Cost Analyses

All repaving projects involve similar design decisions, such as what material should be used and how thick the pavement layer should be. Under state law, MnDOT must conduct a *life-cycle cost analysis* as part of its decision-making process for all pavement projects.[26] As used by MnDOT, life-cycle cost analyses are somewhat similar to benefit-cost analyses, except that they focus entirely on costs. A life-cycle cost analysis combines a project's immediate construction costs with predicted long-term maintenance expenses and reconstruction costs.

Spotlight: U.S. Highway 10, Elk River

MnDOT prepared a life-cycle cost analysis for this 1.1-mile, 4-lane pavement reconstruction project associated with a bridge replacement. The alternatives compared were 6-inch (depth) asphalt, 7.5-inch concrete, and 7-inch concrete. The asphalt alternative had a much deeper sub-base, increasing its initial construction cost.

The results, in costs per mile, are below. (Future costs were discounted using a standard MnDOT formula, as described in Exhibit 2.1.)

	In Thousands		
	6" asph.	7.5" con.	7" con.
Initial cost	$ 894	$ 900	$ 859
Maintenance	12	–	–
New layer (20 yrs)	201	–	–
Rehabilitate (20 yrs)	–	130	179
Maintenance	7	–	–
Replace (35 yrs)	–	–	415
Rehabilitate (35 yrs)	–	99	–
New layer (37 yrs)	134	–	–
Maintenance	5	–	–
Value left (50 yrs)	-25	–	-80
Total	**$1,357**	**$1,248**	**$1,517**

MnDOT selected the 7.5-inch concrete option as the low-cost alternative. Although it had the highest construction cost of the three options, it had lower projected long-term costs.

Life-cycle cost analyses can be performed for any type of infrastructure, as long as future maintenance costs can be predicted. However, like many state transportation departments, MnDOT primarily uses them when choosing among pavement alternatives.

As illustrated in the box at left, a life-cycle cost analysis ordinarily compares two or more possible construction options. For example, reconstructing a pavement segment with concrete may be more expensive in immediate construction costs than using asphalt (bituminous pavement). However, a life-cycle cost analysis may indicate that MnDOT will spend less money on the long-lasting concrete surface over a 35-year or 50-year period than it would spend on maintenance, rehabilitation, and repaving of the less durable asphalt surface.

We examined MnDOT's pavement life-cycle cost analysis process in detail in our 2014 evaluation *MnDOT Selection of Pavement Surface for Road Rehabilitation*, and made several recommendations for improving MnDOT's processes.[27] Because our current evaluation is more broad-based, we did not

[26] *Minnesota Statutes* 2018, 174.185. In implementing this law, MnDOT has exempted preventive maintenance projects and projects with relatively small pavement areas.

[27] Office of the Legislative Auditor, Program Evaluation Division, *MnDOT Selection of Pavement Surface for Road Rehabilitation* (St. Paul, 2014).

examine the life-cycle cost analysis process as closely as we did in 2014. However, we wish to draw attention to two findings from our 2014 report that have not been addressed.

MnDOT does not incorporate public impacts into its pavement life-cycle cost analyses.

MnDOT spends hundreds of millions of dollars on pavement projects each year. However, those construction projects also impose costs on the traveling public—notably time spent in traffic delays and increased vehicle operating costs due to longer trips. When MnDOT chooses a shorter-lasting pavement option, these costs to the public are repeated sooner in the future than if MnDOT chooses a longer-lasting option. MnDOT does not analyze public impacts as part of its life-cycle cost analyses, as we note in the matrix above. Our 2014 review of best practices for life-cycle cost analyses determined that accounting for such costs was a well-established practice that could affect analysis outcomes.[28]

Life-Cycle Cost Analyses: Does MnDOT Analyze These Outcomes?

Short-term state costs **Yes**	Short-term public impacts **No**
Long-term state costs **Yes**	Long-term public impacts **No**

Several other states, such as Washington, incorporate public impacts into life-cycle cost analyses. In one example from a project several years ago, the Washington Department of Transportation planned to widen a state highway segment from two lanes to four lanes. Its initial comparison of concrete and asphalt alternatives found that the long-term construction and maintenance costs were similar, and it selected the concrete alternative based primarily on costs borne by the public. Because the asphalt alternative required more rehabilitation cycles over the 50-year analysis period, the costs to travelers (in construction delays, for example) would be significantly higher than for the concrete option. However, senior department engineers then realized that the original analysis had assumed that future pavement rehabilitation work would occur in the daytime. Reanalyzing the project assuming night construction—when far fewer travelers would be affected—led to a conclusion that the asphalt alternative would, in fact, have lower overall costs.[29]

RECOMMENDATION

MnDOT should incorporate public impacts into its pavement life-cycle cost analyses.

When MnDOT chooses a shorter-term pavement fix over a longer-term fix, the decision has impacts for the public as well as for MnDOT's future budgets. Short-term fixes may mean that pavements will deteriorate more quickly. Further, it means that travel disruptions from maintenance and future construction will also recur sooner. We repeat our 2014

[28] Office of the Legislative Auditor, *MnDOT Selection of Pavement Surface for Road Rehabilitation*, 50-51.

[29] This example is described in Michael J. Markow, *Engineering Economic Analysis Practices for Highway Investment: A Synthesis of Highway Practice*, National Cooperative Highway Research Program Synthesis 424 (Washington, DC: Transportation Research Board, 2012), 76.

recommendation that MnDOT include public impacts in its pavement life-cycle cost analyses.[30]

A statutory requirement that MnDOT use "equal design lives" in life-cycle cost analyses creates unnecessary work and reduces transparency.

Minnesota law defines a life-cycle cost analysis as "a comparison of life-cycle costs among competing paving materials using equal design lives and equal comparison periods."[31] As we discussed in our 2014 report, the requirement for "equal design lives" introduces needless complications into MnDOT's life-cycle analysis process.

As in the Elk River example above, a common life-cycle cost comparison is between a long-lasting concrete alternative with higher construction costs and a short-lasting asphalt alternative with lower construction costs. However, the law's wording requires MnDOT to compare alternatives that have the same design life. As a result, MnDOT adjusts its analyses in awkward ways. For example, MnDOT pavement engineers may meet the legal requirement by adding either an unreasonably thick asphalt layer or an unreasonably thin concrete layer to the life-cycle cost analysis. The artificially created alternative exists only for the purpose of meeting the law's requirements—it is almost never the low cost option and is discarded.

RECOMMENDATION

The Legislature should remove the "equal design lives" requirement from the law requiring pavement life-cycle cost analyses.

The legal requirement that MnDOT compare equal design lives does not prevent MnDOT from choosing the lowest cost pavement alternative. However, it requires MnDOT to conduct additional analyses that do not have a meaningful purpose. We repeat our 2014 recommendation that the Legislature remove the "equal design lives" phrase from the statute.

Value Engineering

Value engineering is a short, intense process in which a team of engineers not associated with a project examine and rethink the project's design parameters. Usually lasting about a week, this intensive project review ordinarily produces a set of recommendations to the project team. The recommendations are focused on increasing the ratio between a project's benefits and costs (though there is rarely a formal benefit-cost analysis). The value engineering team may suggest ways to accomplish the same outcomes while spending less money, or may suggest adding components to improve the overall value of the project. Value engineering studies should occur relatively early in the project development process, before resources already invested in the project design make it difficult to implement changes.

[30] *MnDOT Selection of Pavement Surface For Road Rehabilitation*, 51. That report used the term "user costs" instead of "public impacts."

[31] *Minnesota Statutes* 2018, 174.185, subd. 1(b).

Spotlight: Interstate 35, Lino Lakes to Forest Lake

MnDOT conducted a value engineering study for this complex project, which included three bridge replacements and repaving a six-mile segment of Interstate 35. The value engineering team made eight recommendations, of which the last two were mutually exclusive (it was impossible to adopt both).

1. Redesign a bridge structure to leave more clearance underneath, eliminating the need for pavement reconstruction under the bridge.
2. Build one of the bridges half at a time (lengthwise), so that at least one lane of traffic could be maintained throughout the project.
3. Lower costs by building one of the bridges for slower traffic speeds, appropriate because most bridge traffic turns onto the interstate.
4. Reorganize the order of construction tasks for better traffic flow during construction.
5. Make a technical change limiting preparation of the existing pavement structure.
6. Use asphalt instead of concrete to pave shoulders.
7. Make a technical change to how new concrete would be laid down.
8. Change the paving material on the entire project from concrete to asphalt.

The project team did not adopt the first recommendation but found a different method of accomplishing the same goal. It accepted all other recommendations except for the two involving asphalt pavement (numbers 6 and 8).

The estimated savings from the accepted recommendations was $2.1 million in construction costs. Further, the recommendations regarding traffic flow during construction would reduce disruptions for the public. One accepted recommendation to improve traffic flow was estimated to increase construction costs by $210,000.

Value engineering is encouraged by both federal and state law.[32] FHWA broadly supports value engineering initiatives, and federal law specifically requires that states conduct value engineering studies on federally supported highway projects estimated to cost at least $50 million ($40 million for bridge projects).[33] Minnesota law encourages, but does not require value engineering studies; MnDOT administratively requires studies for any project estimated to cost at least $20 million.[34] For exceptionally large and complex projects, MnDOT requires two value engineering studies at different stages in the project development process.

MnDOT's value engineering process has consistently produced money-saving results.

MnDOT routinely reports to FHWA on the outcomes of all value engineering studies, regardless of whether they were required by federal law. For fiscal years 2015-2018, MnDOT reported that 35 value engineering studies were conducted on roadway construction projects with total estimated costs of $1.78 billion. Across all projects, MnDOT reported that implemented recommendations from value engineering studies had saved an estimated $150 million. The total cost to perform the value engineering studies was $1.9 million.[35]

In the 30 projects that we examined, 16 had value engineering studies. Our review of these studies confirmed that they regularly produced recommendations that led to substantial cost savings for MnDOT projects, as illustrated by the example in the box at left. [36]

[32] See 23 *CFR* 627 (2018); and *Minnesota Statutes* 2018, 174.14 through 174.17. Minnesota law uses the synonymous term "value analysis."

[33] 23 *CFR* 627.5(b) (2018). This provision is limited to projects on the National Highway System, the country's most heavily traveled highways. A little under half of Minnesota's trunk highway network is part of the National Highway System.

[34] Bernard J. Arseneau, Deputy Commissioner/Chief Engineer, *Value Engineering Program Guidelines*, Engineering Services Division Technical Memorandum No. 13-11-TS-04, June 12, 2013.

[35] Minnesota Department of Transportation, "Summary of 10 years of Value Engineering Savings," http://www.dot.state.mn.us/design/value-engineering/documents/fy18-past-savings.pdf, accessed February 19, 2019. MnDOT's reported figures include federal, state, and local contributions to project budgets. The FHWA reports, which include figures for all states, are available at https://www.fhwa.dot.gov/ve/vereport.cfm, accessed February 19, 2019.

[36] MnDOT's reported savings of $150 million relies on estimates and assumptions that are difficult to confirm. MnDOT likely spent tens of millions of dollars less on these projects than it would have otherwise, but we did not confirm the $150 million figure.

However, MnDOT's value engineering recommendations are heavily focused on improvements to the construction process, and pay less attention to long-term impacts.

Value Engineering: Does MnDOT Analyze These Outcomes?

Short-term state costs **Yes**	Short-term public impacts **Yes**
Long-term state costs **Sometimes**	Long-term public impacts **Sometimes**

Although we were impressed with the recommendations by value engineering teams to make construction projects more cost-effective, we observed that most recommendations in the studies we reviewed concerned the construction process itself, as reflected in the matrix at right. Across all the value engineering studies we reviewed, 75 percent of recommendations related to construction issues. Less than 25 percent related to long-term safety, traffic, or environmental impacts. Very few related to long-term maintenance costs. For example, the Interstate 35 value engineering study highlighted above made eight suggestions, almost all related solely to construction techniques or traffic management during construction.

Relatedly, we observed that very few value engineering teams included specialists in maintenance or safety, two fields that might be expected to pay particular attention to long-term impacts of current decisions.[37] In fact, the director of MnDOT's value engineering program told us that she thought it was particularly helpful to have maintenance specialists on value engineering teams. Such specialists, she suggested, add perspectives on how decisions made in the construction process can affect long-term maintenance costs.

RECOMMENDATION

MnDOT should consider adjusting its value engineering process to more explicitly consider long-term outcomes.

Value engineering has an impressive record of accomplishment. However, our review of the value engineering studies in the projects we examined suggested that MnDOT's value engineering teams could pay more attention to long-term outcomes. We do not suggest any significant change to the value engineering process itself. Our recommendation could be implemented through a simple reframing of the instructions offered to value engineering teams or through a broadening of the experts chosen to serve on teams.

Alternative Contracting

The traditional procedure for awarding a construction project to a contractor is referred to as *design-bid-build* contracting. In this process, the transportation agency makes all of the key decisions about what will be built before beginning a bidding process. Once these design decisions are made, the transportation agency publishes the project plans and specifications

[37] We make this observation with some caution. Usually, value engineering reports list team members with a brief specialty (such as "materials," "bridge," or "traffic"). However, team members' full backgrounds may be more extensive. For example, a current materials engineer may have previously spent a decade working in maintenance before shifting to a new position.

Contracting Approaches

Design-Bid-Build. Traditional contracting method. MnDOT designs the project (or hires a design consultant to do so), then contractors bid to build the project to MnDOT's plans and specifications. The contractor bidding the lowest price is typically awarded the contract.

Design-Build. MnDOT solicits bids early in the design process. Winning contractors both complete the design and construct the project.

Construction Manager/General Contractor. MnDOT hires a contractor early in the design process based on qualifications. The contractor and MnDOT work together to complete the design, then negotiate a construction price. If they cannot agree, MnDOT can back out and use the completed design in a traditional bidding process.

and private contractors bid on the project. The lowest bidder is ordinarily awarded the contract.

However, in the past three decades, state transportation departments have pursued other contracting approaches. MnDOT uses two approaches in which the construction contractor is also involved in developing project designs—*design-build* and *construction manager/general contractor* methods.

MnDOT has not pursued alternative contracting approaches as actively as some other state transportation departments (for example, see our discussion of Florida's practices below). Of hundreds of projects slated for construction in Minnesota every year, only around a dozen are considered for design-build or construction manager/general contractor bidding. Generally, these are fairly complex or high-risk projects that MnDOT district offices suggest as likely candidates for alternative contracting.[38]

MnDOT's process for deciding to pursue alternative contracting does not rigorously compare the costs of different contracting approaches.

MnDOT ordinarily uses a committee decision-making process called a "Project Delivery Method Selection Workshop" to recommend whether to use alternative contracting on construction projects. In this process, a group of engineers (including experts on alternative contracting approaches) evaluates the project's suitability for alternative contracting. The committee bases its decision on several criteria, including schedule, complexity, potential for innovation, cost, amount of design work already completed, and potential risks.[39] Ordinarily, the committee reaches a recommendation after a single discussion. District offices make the final decision on whether to use alternative contracting methods.

Practices in Other States

The Florida Department of Transportation (FDOT) has a long history of alternative contracting, particularly the use of design-build contracts. An FDOT senior administrator told us that design-build projects are considered such a normal part of project management that no special procedures exist.

A project manager, with the approval of district leadership, can simply decide that a project is appropriate for a design-build contract. Such decisions are ordinarily based on project urgency and complexity. Cost factors are rarely considered.

The only oversight exercised by the state's central office is to occasionally limit the total number of design-build contracts in a single construction season.

[38] In some instances, MnDOT central office staff ask that a project be considered for alternative contracting.

[39] MnDOT uses some additional secondary criteria if no clear determination can be made from these primary criteria.

The consideration of costs in this committee process is very limited, as we show in the matrix at right. The committee has information on the early estimated costs of the project, but does not use or develop specific estimates of how project costs may differ under each contracting scenario.[40] The committee simply uses its professional judgment to assign a rating for cost to each contracting method on an ill-defined four-point scale. The committee ratings are "++", "+", "–", or "X" (an "X" indicates a "fatal flaw" that would prevent the method from being used). Potential public impacts are not discussed directly, though two of the criteria—project schedule and risks—are related to traveler impacts.

Alternative Contracting: Does MnDOT Analyze These Outcomes?

Short-term state costs **No**	Short-term public impacts **Only indirectly**
Long-term state costs **(Not applicable)**	Long-term public impacts **(Not applicable)**

Spotlight: Smith Avenue "High" Bridge, St. Paul (Highway 149)

This project replaced the bridge deck of this iconic span crossing the Mississippi River.

The participants in the committee process determined that both traditional design-bid-build and construction manager/general contractor approaches would be appropriate for this project. The committee felt the latter approach would be better suited to handle technical complications.

The committee considered design-build less appropriate. The potential for innovative designs was low, some stakeholders might not support design-build, and there was a risk that technical issues might increase costs after a design-build contractor was selected. Further, it was not urgent to start the project soon, which would have been an advantage of the design-build approach.

The committee tentatively recommended that Metro District use design-bid-build contracting, with the potential to shift to a construction manager/general contractor approach if technical complications arose.

Eventually, technical complications did arise, including the discovery of unknown bridge damage. The estimated cost nearly tripled and the project start was delayed. Metro District used the construction manager/general contractor approach.

In the projects we reviewed where MnDOT considered alternative contracting, cost frequently played a minimal role. Decisions were more often based on scheduling concerns, technical complexity, or other factors, as in the example at left.

MnDOT does not assess these judgments after projects have been built to determine whether actual costs matched the assigned ratings. Indeed, it is not clear that it would be possible to do so, since the ratings have no intrinsic meaning and are mostly used comparatively.

MnDOT's limited emphasis on financial assessment appears to conform to the national literature on alternative contracting.

Our review of the literature on alternative contracting suggests that the primary purpose of alternative contracting is not to produce cost savings. Instead, alternative contracting approaches are generally viewed as techniques to address project complexity, encourage innovative solutions to problems, limit risk, and meet tight schedules. However, one goal of alternative contracting is to increase the *predictability* of costs by shifting the responsibility for some risks from the state agency to the contractor.

[40] We do not discuss long-term costs or public impacts in this section or show them in the matrix. Generally, the choice of contracting method is not a decision about what will be built. Therefore, there are no long-term outcomes to assess. Alternative contracting approaches are intended to foster more innovation by contractors, which could affect long-term outcomes. However, the decision to use an alternative contracting method would occur before any contractor-suggested innovations would be proposed or evaluated.

RECOMMENDATION

MnDOT should consider incorporating more detailed cost and public impact information into its alternative contracting decision process.

It is difficult to make firm cost comparisons across different contracting methods when planning projects. Such comparisons require predictions of what would happen under different future scenarios. Predicting the future is difficult in any case; it is more difficult because MnDOT has not systematically tracked how well projects built using alternative contracting approaches have met project budget estimates.[41]

Nonetheless, we believe MnDOT could do more to support the cost assessments that appear in its internal documentation of the selection of contract methods. Rather than (or perhaps in addition to) the cryptic "++" and "+" ratings, MnDOT's documentation should at least record the size of the costs and risks assessed by the committee. For example, suggesting that one approach could cost $10 million less than another in a best-case scenario would clarify how much better that alternative appears on the cost criterion.

We also recommend that MnDOT begin gathering systematic data on the extent to which projects delivered through alternative contracting approaches fall within expected budget ranges. However, we acknowledge that at MnDOT's current rate of using alternative contracting methods, it may be years before sufficient data exists to form firm conclusions.

Lastly, we suggest that MnDOT more directly assess the potential public impacts of differing contracting approaches. If alternative contracting methods provide distinct advantages or disadvantages in terms of likely construction disruptions for travelers, those factors should be included in MnDOT's alternative contracting decision process.

[41] MnDOT staff have systematically tracked the post-letting costs of projects constructed using alternative contracting. That is, they have tracked how much additional money MnDOT agreed to pay to the contractor after the contract was awarded due to design errors, changed specifications, or unforeseen problems. According to MnDOT staff, design-build and construction manager/general contractor projects generally have fewer costs added after bidding than comparable design-bid-build projects.


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Chapter 5: Maintenance

MnDOT's Office of Maintenance provides support and guidance regarding maintenance and operational activities to MnDOT's eight district-level maintenance offices. MnDOT defines highway maintenance as "the preservation of all types of roadways, roadsides, structures and facilities as close as possible to their original condition."[1] Maintenance activities include repairing deficient infrastructure, such as patching pavement potholes and cleaning drainage pipes, and services that ensure safe and satisfactory conditions, such as clearing debris or snow and ice from roadways. Unlike road construction projects, which are completed by contractors, maintenance work is typically completed by MnDOT's own staff.[2]

In this chapter, we describe the extent to which MnDOT's maintenance units incorporate financial effectiveness considerations in their decision making. As in chapters 3 and 4, our guiding framework relies on the two dimensions of decision making we discussed in Chapter 2: does MnDOT assess short-term and long-term outcomes, and does it assess outcomes for both MnDOT and the general public? To be financially effective, MnDOT's central and district-level maintenance decision makers should examine outcomes in all four quadrants of the matrix at right. To the extent feasible, such examinations should be analytic and evidence-based, and not drawn solely from informal professional judgment.

Outcomes MnDOT Should Analyze to Address Financial Effectiveness in Maintenance Activities

Short-term state costs How a decision will affect maintenance costs	**Short-term public impacts** How a decision will affect the public during maintenance work
Long-term state costs How a decision will affect future costs (due to maintenance or reconstruction needs, etc.)	**Long-term public impacts** How a decision will affect the public in the future (by altering travel times, safety, the environment, etc.)

We first discuss the planning and budgeting for MnDOT's maintenance activities. We then discuss MnDOT's research program for identifying new maintenance technologies and strategies.

Planning and Budgeting

MnDOT's maintenance activities address a broad range of responsibilities, as shown in the box on the next page. MnDOT's organizational structure for carrying out these tasks is highly decentralized. Nearly all decisions about allocating resources and prioritizing among

[1] Minnesota Department of Transportation, Office of Maintenance, *2014 Maintenance Manual* (St. Paul, 2014).

[2] MnDOT uses the term "maintenance" in multiple ways. MnDOT sometimes refers to large-scale preservation projects, such as sealing the cracks on several miles of highway, as "preventive maintenance." However, such activities are often contracted out and funded out of the state road construction budget, not the maintenance budget. In this chapter, we address activities performed by maintenance staff using maintenance funds.

different tasks are made by district maintenance offices.[3] Within district offices, some decision making may be further decentralized to individual maintenance units.

MnDOT Maintenance Activities

Roads and roadsides
- Clearing snow and ice
- Patching pavement potholes
- Inspecting and repairing drainage pipes
- Maintaining and controlling roadside vegetation
- Maintaining or replacing pavement markings
- Removing graffiti and litter
- Repairing traffic and safety barriers
- Replacing highway signage

Bridges and other structures
- Inspecting and repairing bridges
- Inspecting and repairing other structures, such as noise walls, retaining walls, overhead signs, and lighting systems

Arterial and freeway operations
- Managing traffic signals, freeway ramp meters, and traffic cameras
- Responding to traffic incidents

Fleet and facility management
- Inspecting, upgrading, and replacing equipment
- Inspecting and maintaining MnDOT buildings

Most maintenance work addresses observed or reported problems. Each year, district maintenance offices develop work plans based on their own assessments of these problems and the amount of maintenance work required to address them.[4] Throughout the year, maintenance offices learn of more problems that need to be addressed and slot them into the work plans, reshuffling other priorities to make room. District maintenance units generally give top priority to problems constituting immediate threats to safety—such as snow-covered roads, large potholes, or drainage backups. Problems that pose minimal threats to motorists, the general public, or the environment—such as damaged noise barriers—may be postponed repeatedly.

The formality of the work plan development process and the format of the plans themselves vary from district to district. For example, Metro District's maintenance office has created a detailed listing of maintenance priorities to guide its field staff. The listing includes 31 different activities ranked by level of importance, ranging from emergency response activities at the highest priority to the mowing of MnDOT-owned vacant lots at the lowest. Some other districts, by contrast, rely on unwritten, informal rules to prioritize their various maintenance needs.

MnDOT's management of its maintenance activities does not systematically address financial effectiveness.

MnDOT's maintenance decision making focuses heavily on immediate costs and impacts, as shown in our matrix on the next page. In fact, MnDOT does not currently have in place the databases, performance measures, or accounting systems it would need to assess long-term outcomes and increase the cost-effectiveness of its maintenance decisions.

[3] An important exception is fleet management; the central Maintenance Office, not districts, makes decisions about vehicle purchases.

[4] For nonroutine problems, district maintenance staff may also consult with specialists in other offices, such as the Bridge Office, the Hydraulics Office, or the Materials and Road Research Office.

Maintenance Planning and Budgeting: Does MnDOT Assess These Outcomes?

Short-term state costs **Yes**	Short-term public impacts **Yes**
Long-term state costs **No**	Long-term public impacts **No**

Transportation agencies in many states have moved toward maintenance management approaches that emphasize accountability, performance measures, and cost-effectiveness. A 2012 study found that 31 out of 41 surveyed state transportation agencies reported using a performance-based approach to manage maintenance activities. However, "performance-based" meant different things to different respondents. Only eight responding agencies agreed that they had "a mature program of maintenance and operations levels of service (including any underlying performance measures) that is well integrated in management procedures, assessments, decisions, and systems."[5]

Over 30 years ago, we recommended that MnDOT adopt a more performance-based planning and budgeting approach to highway maintenance. Our 1985 *Highway Maintenance* evaluation recommended that MnDOT develop and implement a "maintenance management system," a systematic approach to planning and delivering an efficient and performance-based maintenance program.[6] We wrote:

> A well-designed and properly implemented maintenance management system should enable the Minnesota Department of Transportation to better plan and schedule work. Improved historical data about workload and costs will help to improve plans for future work and will also support investment decisions for highway improvements. The maintenance management system will help to identify areas of high-cost maintenance which would benefit from improvements.[7]

MnDOT has still not fully implemented this recommendation. We highlight below three components of financially effective maintenance management that MnDOT has yet to fully implement. We suggested that all of these be part of the maintenance management system that we recommended in 1985.[8]

Infrastructure inventories. In order to cost-effectively plan maintenance activities over the long term, a transportation agency needs to identify the infrastructure elements it maintains, their current condition, and their likely rate of deterioration.[9] MnDOT has developed extensive inventories for its most important infrastructure, the state's pavements and bridges. However, MnDOT has not historically documented or monitored the roadside

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[5] Michael J. Markow, *Performance-Based Highway Maintenance and Operations Management*, National Cooperative Highway Research Program Synthesis 426 (Washington, DC: Transportation Research Board, 2012), 15.

[6] Office of the Legislative Auditor, Program Evaluation Division, *Highway Maintenance* (St. Paul, 1985).

[7] *Ibid.*, 39.

[8] Others have also highlighted the importance of these elements of a well-structured maintenance management system. See, for example, American Association of State Highway and Transportation Officials, *Guidelines for Maintenance Management Systems* (Washington, DC, 2005).

[9] Such inventories may also keep track of ongoing maintenance responsibilities that are not "infrastructure," such as areas of vegetation that maintenance crews must maintain.

infrastructure it is also responsible for maintaining, including retaining walls, some drainage structures, light towers, and noise barriers.

Expenditure tracking. Planning maintenance activities cost-effectively requires an understanding of how much specific tasks cost. MnDOT has not historically recorded this information about its maintenance spending. MnDOT has used staff timesheets to gather some information about the amount of staff resources spent on specific maintenance tasks, but this information has not consistently included equipment or material costs. Further, information on the amount of time spent on a task is of limited value without knowing the extent of the repair work accomplished during that time. Without more detailed information, it is impossible to develop a complete understanding of the relationship between maintenance activities, performance outcomes, and spending.

Performance measures. Performance measures enable a transportation agency to assess whether its maintenance activities are producing the intended benefits. MnDOT's performance measures for its maintenance program are not fully developed. For example, the department has no performance measures or targets for pavement patching or roadway shoulder work. MnDOT has performance measures and targets for drainage repairs, but applies these only to drainage pipes that cross under the highway centerline; MnDOT does not systematically assess its performance maintaining drainage pipes parallel to highways that cross under driveways or local roads. In addition, MnDOT does not have performance measures for some of its service-oriented tasks, such as removing debris and litter and mowing roadside grass. On the other hand, MnDOT does have well-developed measures for snow and ice removal.

Some relevant performance data do exist, but are controlled by other MnDOT offices. For example, the Bridge Office tracks the percentage of completed inspections for bridges and underground pipes, and the Materials and Road Research Office tracks the smoothness of road surfaces throughout the state. But these data systems do not track the frequency or cost of all routine maintenance activities to repair bridges, pipes, and pavements.

MnDOT district maintenance budgets are not based on needs or cost-effective maintenance strategies.

Districts' overall maintenance budgets are not based on work plans, an analysis of maintenance needs, or expected outcomes. Instead, MnDOT allocates districts' maintenance budgets based on the amount of funding they received the prior year. According to MnDOT financial staff, although no specific formula is currently used, these allocations generally correlate with the size of each district's road network, the amount of money it receives for construction projects, and the number of its full-time employees. If MnDOT receives additional funds for maintenance from the Legislature or other sources, it distributes them using several different methods that change from year to year.[10]

District maintenance offices spend their budget allocations on district-defined priorities. Given the lack of performance measures and detailed accounting data, it is impossible for district maintenance offices to systematically optimize their spending patterns. For example, when the Metro District maintenance office developed its priority listing of

[10] MnDOT is currently conducting a study to develop a new formula for distributing maintenance funding to districts.

maintenance tasks, it did so primarily through a survey of district maintenance leadership; it did not analyze performance outcomes or long-term maintenance costs. That being said, district maintenance staff may make decisions on a case-by-case basis that, in their professional judgment, produce more cost-effective outcomes. For example, a district may limit its maintenance activities on a road scheduled for more extensive road construction work in the near future.

Practices in Other States

The Washington State Department of Transportation (WSDOT) develops its biennial maintenance budget by identifying its statewide maintenance priorities, their associated performance targets, and cost estimates for achieving each level of performance.

WSDOT ranked 31 statewide maintenance priorities for the 2017-2019 biennium, such as ferry and bridge operations, snow and ice operations, and pavement patching. Each priority was associated with a performance target, the amount of money spent on similar activities in the previous biennium, and the level of performance achieved in the last year of the previous biennium.

For example, "special bridge and ferry operations" was the top maintenance activity for the 2017-2019 biennium. WSDOT expected bridge and ferry activities operate at the highest service level, so that there would be few delays. WSDOT had spent $10.9 million on bridge and ferry operations in the 2015-2017 biennium.

WSDOT drew upon this information to develop its budget request for maintenance activities to the Washington Legislature. WSDOT's regional offices also use these statewide priorities to plan and budget their maintenance programs.

In the box at right, we describe the different approach taken by Washington, a state with a long history of systematic maintenance management. The Washington Department of Transportation explicitly bases its maintenance budgeting on performance measures and expected outcomes, and it uses those assessments to frame its funding requests to the state legislature.

MnDOT's development of a new infrastructure database could improve the financial effectiveness of its maintenance decisions.

Although MnDOT does not yet collect the information it needs to analyze the financial effectiveness of its maintenance decisions, it has made significant progress in the last few years. In 2014, as part of a federal initiative, MnDOT was one of the first three state transportation departments to develop a risk-based transportation asset management plan. That planning process identified MnDOT's lack of data on infrastructure beyond pavements and bridges as a key problem.

As an outcome of this planning process, MnDOT is currently developing a Transportation Asset Management System (TAMS). TAMS is a database that will store information on infrastructure condition and will record most of MnDOT's maintenance activities and spending. As part of the database development process, MnDOT has for the first time documented the exact locations of many of its roadside infrastructure elements, such as retaining walls, light tower poles, noise barriers, and overhead signs. TAMS will also store information about MnDOT's pavements, pulling data from the department's pavement computer model (which we discussed in Chapter 3) and tracking related maintenance activities and their associated maintenance costs.[11] In short, TAMS is intended to allow

[11] MnDOT also plans to integrate parts of its bridge data systems into the TAMS as part of a future update.

administrators to track MnDOT's maintenance activities and costs at a granular level.[12] MnDOT plans for TAMS to become operational in April 2019.

Once TAMS is fully operational, MnDOT district maintenance offices should have access to a wealth of data that has not previously been available to them. MnDOT staff told us that TAMS will improve the department's ability to calculate long-term costs and public benefits of maintenance activities. MnDOT will be able to use TAMS data to analyze approximately how much money it costs for the department to achieve performance targets for maintenance work. For example, TAMS will record the number of signs that MnDOT crews repair and how much it costs them to do so. Eventually, MnDOT will be able to use these cost benchmarks to develop statewide maintenance priorities informed by long-term costs. Ideally, these efforts will guide how districts plan their maintenance programs.

RECOMMENDATION

MnDOT should incorporate measures of cost-effectiveness into its maintenance plans and budgets.

MnDOT should plan as many of its maintenance activities as possible using data on actual needs, actual costs, and performance outcomes. The department should not only continue to develop new maintenance performance measures, but also set expectations for district performance.

TAMS presents an important opportunity for the department and districts to use newly available data to improve maintenance management. As visualized in its Transportation Asset Management Plan, MnDOT should use these new resources to develop statewide maintenance priorities, performance measures, and best practices to provide the most benefit to the public while minimizing costs.

However, we note that state agencies have a mixed track record when seeking to speed services and reduce costs through the development of new computer systems or tools. We encourage the Legislature to seek regular updates from MnDOT on its progress in using TAMS to improve the cost-effectiveness of maintenance activities.

Research

MnDOT staff often assess new maintenance equipment or maintenance techniques to see if existing methods can be improved. MnDOT supports these explorations through its Maintenance Operations Research program, which provides extra funding to districts that want to experiment with new equipment or techniques. In fiscal years 2016 and 2017, the program funded 45 research projects on new equipment or techniques at a total cost of $440,000. Examples included a specialized camera for inspecting gaps underneath pavements before inserting filler material and a grappling device for removing debris from culverts and other hard-to-reach areas.

[12] TAMS may not encompass all MnDOT maintenance activities. For example, MnDOT-owned buildings (such as rest areas, salt sheds, and MnDOT offices) and pavement markings have their own separate inventories, which may not be integrated into TAMS.

In order for a district to participate in the Maintenance Operations Research program, it submits a proposal explaining the new method it would like to test and how much time it will need for testing. After MnDOT approves a proposal and a district has finished its testing, districts submit an evaluation form to MnDOT's maintenance office describing the outcomes of their testing of the new equipment or techniques.

MnDOT does not consistently consider cost-effectiveness when comparing various maintenance techniques and equipment.

MnDOT does not rigorously assess either the short-term or long-term costs of the tested maintenance methods. The Maintenance Operations Research program does not require that districts explicitly compare the costs of the tested methods to current practices, nor does it ask districts to assess whether the new methods will provide long-term savings. Further, the program accepts fairly anecdotal reports of the likely impacts of the new methods.

Maintenance Operations Research Program: Does MnDOT Assess These Outcomes?

Short-term state costs **No**	Short-term public impacts **No**
Long-term state costs **No**	Long-term public impacts **No**

MnDOT's maintenance research unit convenes two committees to assess research proposals and award funding, one for proposals seeking over $15,000 and the other for smaller proposals. Both committees use the same criteria, including innovation, safety improvements, and potential cost savings. Although cost savings (through reduced equipment costs, reduced staff needed, or increased speed) is a criterion, committee members have evaluated whether proposed new equipment or technology may save costs based on very limited descriptions—often little more than a single sentence.[13]

We reviewed 19 proposals funded by the Maintenance Operations Research program in 2017 and 17 evaluations of completed research submitted in 2018.[14] Among the proposals that we reviewed, 14 suggested the new equipment or techniques would save money but did not provide a comparison of costs between the new method and MnDOT's practices at the time that the proposal was made. Districts' research proposals included only costs necessary to carry out the research. There appeared to be no relationship between the amount of money that could be saved and the committee's assessments of the proposed research projects.

[13] Our assessment is based on the project proposals submitted in 2017. That form provided check boxes for "saves time," "saves manpower," "saves money," "saves material," "reduces injuries," and "reduces accidents," with space for a brief written comment next to each box. MnDOT is now using a new form with check boxes for only three categories—"saved costs," "improved quality," and "improved safety."

[14] We reviewed proposals and evaluations in different years so we would have examples of proposals and evaluations for the same project. Eleven projects with proposals funded in 2017 also had evaluations in 2018. We did not review proposals for applications seeking over $15,000 in funding because those proposals included an in-person presentation to the funding committee, which might have provided the committee with additional information we would be unable to access. The project proposals and evaluations that we reviewed for the Maintenance Operations Research program are separate from the sample of 30 construction projects that we described in Chapter 4.

Spotlight: Research on New Equipment

Headlights: In 2017, District 3 tested new headlights for snow plow trucks. In its research proposal, the district suggested the new lights had the potential to last longer and require less maintenance over the life cycle of the truck. After testing, the district's evaluation concluded that the new lights produced safety benefits due to increased night visibility. The evaluation did not mention whether the lights lasted longer, required less maintenance, or whether they cost more or less than the previously used lights.

Mower: District 2 tested a new remote control mower in 2017 to control vegetation on steep slopes and wet areas. The district's proposal stated that MnDOT's standard process of using tractors to mow such areas sometimes led to rollovers, threatening staff safety and posing high repair costs. The district's evaluation concluded the mower led to fewer expensive repairs and better safety. However, the district provided no details, such as a comparison of the repair costs experienced with the new and old methods. Additionally, there was no indication of how much the new mower cost.

District staffs' evaluations of the new maintenance approaches were also limited in their review of cost-effectiveness. The evaluations we reviewed that reported lower costs offered only anecdotal information as evidence, as illustrated by the examples in the box at left. In only one instance did a district's evaluation compare the cost of the new equipment or method to alternatives.

Further, evaluations tended to focus on short-term benefits, such as the ease of using equipment and immediate safety improvements. Only two of the evaluations we reviewed directly discussed long-term outcomes. In 2017, for example, District 7 suggested that a new pavement sealant could provide longer-lasting concrete fixes than current methods, requiring fewer recurring maintenance repairs and reducing agency costs over time. The district also mentioned potential long-term public impacts, including safer driving conditions as a result of fewer pavement potholes.

RECOMMENDATION

MnDOT should explicitly evaluate the cost-effectiveness of new maintenance equipment and techniques.

We endorse the efforts of the Maintenance Operations Research program to promote innovation and experimentation. However, MnDOT should assess the cost-effectiveness of new ideas brought forth by district maintenance staff. The maintenance office should require that proposals and evaluations for the tested methods explicitly compare costs to past practice. Even if the primary benefit of the new approach is something other than cost (for example, improved performance or safety), evaluations should frame the advantages gained in terms of the costs incurred. For example, a moderate gain in performance for a large increase in cost may not be a good trade-off. Conversely, a clear gain in safety may be considered worthwhile even if costs double or triple.

List of Recommendations

- The Legislature should reconsider its requirement that MnDOT report on financial "efficiencies." (p. 11)
- MnDOT should incorporate sensitivity analysis into its standard benefit-cost methodology. (p. 17)
- When assessing financial effectiveness, MnDOT should consistently examine: (1) short-term and long-term outcomes, and (2) outcomes for MnDOT and the general public. (p. 20)
- MnDOT should develop guidance on the use of cost-effectiveness measures in planning studies. (p. 24)
- MnDOT should consider formally including long-term public impacts in the computer models that facilitate its project selection processes. (p. 27)
- MnDOT should reexamine its cost-effectiveness policy. (p. 37)
- MnDOT should consider developing better documentation of the financial elements that inform project scoping decisions. (p. 38)
- MnDOT should develop additional procedures to ensure its staff adhere to the performance-based practical design policy. (p. 41)
- MnDOT should incorporate public impacts into its pavement life-cycle cost analyses. (p. 43)
- The Legislature should remove the "equal design lives" requirement from the law requiring pavement life-cycle cost analyses. (p. 44)
- MnDOT should consider adjusting its value engineering process to more explicitly consider long-term outcomes. (p. 46)
- MnDOT should consider incorporating more detailed cost and public impact information into its alternative contracting decision process. (p. 49)
- MnDOT should incorporate measures of cost-effectiveness into its maintenance plans and budgets. (p. 56)
- MnDOT should explicitly evaluate the cost-effectiveness of new maintenance equipment and techniques. (p. 58)


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395 John Ireland Blvd.
Saint Paul, Minnesota 55155

February 28, 2019

Mr. Jim Nobles, Legislative Auditor
State of Minnesota
Office of the Legislative Auditor 658
Cedar Street, Room 140
St. Paul, MN 55155

Dear Mr. Nobles:

The Minnesota Department of Transportation (MnDOT) has reviewed the evaluation report entitled "MnDOT Measures of Financial Effectiveness." Improving our financial effectiveness has been a long-standing goal of the Department, and we appreciate your staff's efforts to make the measurement of financial effectiveness more robust and to help us continue to get as much benefit as we can from each transportation dollar spent.

We are pleased that the report affirms many efforts that MnDOT is working on to improve our abilities to measure and use financial effectiveness in our decision making processes. In particular we appreciate the acknowledgment for these efforts.

- MnDOT appreciates the Auditor's recognition of the complexity of doing a comprehensive benefit/cost analysis and the inherent difficulties of estimating and monetizing each potential factor that MnDOT or the public might see as a benefit. MnDOT accepts the report's labeling of its standard benefit/cost methodology as "conservative" and will continue to adopt new benefit categories when evidence warrants. (Chapter 2)

- The new Pavement Investment Guide, still in development, will provide MnDOT District decision-makers new tools to optimize the performance of their pavement system. A vital part of this effort involves the creation of new measures that will help make more informed decisions. The Guide is expected to be implemented in 2020. (Chapter 3)

- MnDOT implemented performance-based practical design (PBPD) principles through the 2017 policy adoption. PBPD focuses on using design flexibility available within and outside the standard ranges of road design criteria and fixing only what is necessary that will result in a better return on investment, using actual performance data to help make design decisions.

MnDOT is currently in the process of updating our MnDOT Road Design Manual that will incorporate many of the PBPD principles that designers will use on their projects. (Chapter 4)

- The Transportation Asset Management System (TAMS) has been developed to inventory and support more robust management of the most significant roadway, bridge, and supporting assets (Chapter 5). When complete, this implementation will address the recommendations set forth in the Highway Maintenance audit.

- Related to TAMS is the Transportation Asset Management Plan (TAMP). One of the key tenets of the TAMP is consideration for long term stewardship of our assets. The TAMP is written for the purpose of optimizing the efficiency of managing our assets covered in the TAMP. MnDOT is committed to ensuring implementation of the TAMP in its decentralized structure through training workshops, development of Key Performance Indicators, and development of an Asset Management Policy. (Chapter 5)

Recommendation #1 The Legislature should reconsider its requirement that MnDOT report on financial "efficiencies" (Chapter 2)

- MnDOT agrees that the requirements to report on efficiencies produce an incomplete picture that does not represent MnDOT's true accomplishments for generating cost savings through value engineering, adopting innovative practices, research implementation, performance-based practical design, and a host of other activities.

- Other current and potential methods that more comprehensively describe cost savings achieved across the range of MnDOT activities include:
    - Value Engineering Annual Report
    - Monthly Letting Analysis (reports low bid against programmed amount)
    - Research implementation benefits quantification measures
    - Performance-based practical design policy measures

Recommendation #2 MnDOT should incorporate sensitivity analysis into its standard benefit/cost methodology. (Chapter 2)

- MnDOT agrees that sensitivity analysis can be a helpful addition to benefit/cost analysis. MnDOT will review the sensitivity procedures and parameters recommended by federal and other state transportation agencies to determine appropriate guidelines for use in Minnesota.

As suggested in the report, tradeoffs will be considered between, (a) the level of effort required to conduct the proposed sensitivity analysis, and (b) the financial effectiveness value expected to be gained from inclusion of new proposed sensitivity factors.

- MnDOT uniformly sets benefit/cost guidance and monetization rates for benefits such as the value of travel time savings. However, most project-level benefit/cost analysis is conducted by independent consultants—frequently in conjunction with required environmental assessment. For this reason, instructions for sensitivity ranges will be written that do not specify specialized modeling inputs or software and that can readily be implemented by a broad base of users.

- In a one-time competitive solicitation offered five years ago, MnDOT experimented with benefit/cost sensitivity analysis through the use of probabilistic input ranges and a Monte Carlo statistical simulation. While these earlier efforts appropriately acknowledged the uncertainty accompanying all benefit/cost studies, MnDOT found it challenging to establish transparent decision rules for comparing more complex results of candidate projects. MnDOT will take this experience into account when introducing the new sensitivity scope and procedures.

- Monetization factors for benefit/cost evaluation are regularly reviewed and updated annually each July at the start of the state fiscal year, for incorporation in project studies initiated that year. MnDOT anticipates formulating and publishing provisional sensitivity guidance over the course of the next two update cycles.

Recommendation #3 When assessing financial effectiveness, MnDOT should consistently examine: (1) short-term and long-term outcomes, and (2) outcomes for MnDOT and the general public. (Chapter 2)

- MnDOT would like to have the ability to always assess financial effectiveness of short-term and long-term outcomes for both MnDOT and the general public, but can be limited by data availability, evaluation tools and financial resources. In some situations the added expense and time to perform the analysis may not add value to the decisions being made. In other situations, the benefits are not easily quantifiable (e.g. the value of historic preservation or litter-free roadsides). Finally in some instances, there are really no options to evaluate (e.g. emergency repairs).

- MnDOT will create additional guidance on when and how to include short and long-term costs to create consistency in the various types of analyses that are performed to assess financial effectiveness. This activity will address the other recommendations where relevant.

Recommendation #4 MnDOT should develop guidance on the use of cost-effectiveness measures in planning studies. (Chapter 3)

- MnDOT agrees that some planning studies (those that identify specific projects or improvements) should include some evaluation of cost-effectiveness.

- Within the next year, MnDOT will determine which planning studies should include cost-effectiveness analysis and create appropriate guidance for MnDOT studies and for studies that MnDOT helps fund or is a primary partner.

Recommendation #5 MnDOT should consider formally including long-term public impacts in the computer models that facilitate its project selection processes. (Chapter 3)

Pavements

- MnDOT is near deployment of a new pavement modeling tool (Chapter 3) that will allow MnDOT Districts to better evaluate alternatives to the statewide model. It will also enable the calculation of a wider variety of performance measures. The new tool will enhance MnDOT's ability to consider other factors and choose the most cost-effective alternatives.

- MnDOT will consider how the pavement model considers short and long-term costs for the state and the users, clarify how the models address those costs presently, and make recommendations for practical improvements in future upgrades to the software.

Bridges

- MnDOT's bridge model does not calculate the long-term maintenance costs. However, long-term maintenance considerations are built into the logic for the recommended repair based upon factors such as historical bridge design criteria and materials that predict how the bridge may likely perform in the future under various repair strategies.

- Regarding the Auditor's observations on the use of numerical thresholds as proxies for a cost-effectiveness analysis in project selection (Chapter 3), MnDOT uses the 30 and 70 percent thresholds as an early indication of how extensive a project is necessary to address bridge

deficiencies. Although not based on formal research, those thresholds were developed based upon years of experience with the development of bridge projects. MnDOT will review/validate the cost thresholds with analysis of current information.

- MnDOT plans to develop a life cycle cost model to compare various bridge work types and include long-term costs. However, ongoing maintenance and inspection costs represent a small fraction of the life cycle costs for most bridges. Long-term costs average about $0.30 per square foot per year on bridge maintenance and inspection. That is a small amount compared to approximately $200 per square foot to replace a bridge or $75 per square foot to redeck a bridge.

Recommendation #6 MnDOT should reexamine its cost effectiveness policy. (Chapter 4)

- MnDOT acknowledges that the current policy does not uniformly apply to all agency projects. At the same time, we agree with the report's concluding point on the limitations of benefit/cost analyses: "perhaps most importantly, [they] do not measure certain characteristics that are important to decision makers" (Chapter 2), or for that matter, the public.

- When reexamining its cost effectiveness policy, MnDOT will weigh the role of these external factors—as well as other financial effectiveness measures addressed elsewhere in these evaluations—to reevaluate the qualification criteria governing which projects are subject to the cost effectiveness policy.

- We endorse the report's view that, "MnDOT should pay closer attention to the comparisons of benefit/cost ratios across project alternatives." (Chapter 4) However, this finer evaluation need not entail a "de-emphasis" of the current policy's stated benefit/cost ratio threshold (equal to 1.0), indicating a project's benefits are expected to exceed its costs. Indeed, the fact that the majority of tested projects clear this threshold is an important confirmation of financial effectiveness within the portfolio of significant capital projects.

- To support the best use of constrained funding, MnDOT commits to strengthening the terms of the cost effectiveness policy to cover cases where multiple project alternatives are found to be "cost-effective" in the narrow sense of having a benefit/cost ratio greater than 1.0.

Recommendation #7 MnDOT should consider developing better documentation of the financial elements that inform project scoping decisions. (Chapter 4)

- MnDOT agrees that financial effectiveness considerations are not consistently documented in project scoping documents.

- MnDOT is currently engaged in revising the Highway Project Development Process (HPDP) resources and will include this as one of the topics to be reviewed and updated. The HPDP update is expected to be complete in approximately one year, but is an ongoing effort.

- MnDOT is working with the Federal Highway Administration to develop curriculum and deliver training to project managers on the scoping process. Documentation of alternatives analysis and financial considerations will be included in this training.

Recommendation #8 MnDOT should develop additional procedures to ensure its staff adhere to the performance-based practical design policy. (Chapter 4)

- MnDOT agrees with the observation of the Auditor that "performance-based practical design holds considerable promise from a financial effectiveness perspective." As stated, although the concepts of practical and performance-based design (PBPD) have been around for a number of years, MnDOT has only recently adopted it as a policy, and technical guidance was published only last year (2018).

- Previous and current efforts to measure cost efficiencies on account of practical design have proven challenging, since a baseline against which to measure cost savings is difficult to establish and somewhat arbitrary. This is due to the inherently flexible and open-ended nature of roadway engineering.

- MnDOT's policy directs its design professionals to apply PBPD processes and criteria where practicable on every project. However, while MnDOT can direct the professional engineer responsible for designing the project to apply PBPD principles, MnDOT design engineers must always act in accordance with the professional standard of care for a licensed engineer. As stated in Minnesota Rules 1800.4200, the design engineer is "the person whose professional skill and judgment are embodied in the document signed, and who assumes responsibility for the accuracy and adequacy thereof."

- Given these considerations, MnDOT agrees to continue to provide education, support and encouragement for PBPD – to internal MnDOT staff as well as to the municipal, county and consulting engineering communities – and to seek a more effective measure for when it has been applied and the savings experienced.

- In addition, MnDOT is updating its Highway Project Development Process (HPDP) and drafting a new Facility Design Guide (which will replace the current Road Design Manual). Both will integrate PBPD into our standard design guidance.

Recommendation #9 MnDOT should incorporate public impacts into its pavement life-cycle cost analyses. (Chapter 4)

- The Legislative Auditor made a similar recommendation in its 2014 report, recommending MnDOT develop a process for estimating user costs for road rehabilitation for competing pavement alternatives. At that time, MnDOT responded that prediction of what will happen to a pavement 30-50 years in the future with enough specificity to accurately measure users' costs is not practical. MnDOT further noted that experts in different fields do not agree on how to appropriately consider user costs over very long time periods.

- MnDOT does consider shot-term user costs resulting from pavement type decisions in other ways, such as project staging and work scheduling.

- MnDOT will continue to research methods to incorporate public impacts in its pavement selection process.

Recommendation #10 The Legislature should remove the "equal design lives" requirement from the law requiring pavement life-cycle cost analyses. (Chapter 4)

- MnDOT supports this recommendation and agrees that our ability and commitment to selecting the lowest cost pavement alternative will not be diminished by repealing this requirement.

Recommendation #11 MnDOT should consider adjusting its value engineering process to more explicitly consider long-term outcomes. (Chapter 4)

- MnDOT appreciates affirmation of the Value Engineering program and agrees that long-term costs can be an important consideration when assessing construction costs. This aligns with MnDOT's desire to continuously improve the Value Engineering program.

- VE teams typically make recommendations on roadway material types and bridge repairs that will provide the lowest cost alternative based on a specified time duration, most typically 20 years. These comparisons include capital costs, costs to repair and maintenance costs.

- MnDOT will clarify the instructions provided to Value Engineering teams to consider long-term outcomes. MnDOT will also add a maintenance representative to the teams to assure the maintenance perspective is considered. MnDOT does concur with footnote #37 that many Value Engineering team member's full backgrounds are often more extensive than the highlighted specialty might suggest.

Recommendation #12 MnDOT should consider incorporating more detailed cost and public impact information into its alternative contracting decision process. (Chapter 4)

- MnDOT agrees with the observations of the auditor on the difficulty of measuring the savings achieved by alternative delivery methods. At the time the delivery method process takes place, many details about the project are still unknown. Commonly, the only information available for an evaluation of financial effectiveness is a rough planning level cost estimate, a general scope, and a worst-case scenario of impacts, which makes estimating user costs problematic. MnDOT also agrees that at the current frequency of alternative delivery projects, it will take some years to compile a good bank of data for all delivery methods.

- Given those limitations, MnDOT commits to investigating cost and impact factors that may be considered during the alternative contracting decision process, including:
    - Road user costs and project risk and opportunities at the project level that can be included in the delivery method selection process.
    - Improved performance measures across all delivery methods, tracking performance, and then using that information to support the delivery method selection process.

Recommendation #13 MnDOT should incorporate measures of cost effectiveness into its maintenance plans and budgets. (Chapter 5)

- MnDOT agrees with the observations of the Auditor that cost effectiveness should be a contributing factor in maintenance plans and budgets.

- Establishing and tracking maintenance performance measures aids demonstrating the cost effectiveness of maintenance plans and budgets. MnDOT currently uses performance measures both for the condition of some assets, such as pavements, and for some services provided, such as snow removal. Since concluding its "Asset Management Gap Study," MnDOT has been pursuing the creation/development of numerous additional performance measures, targets, and prioritization metrics in an effort to expand the breadth of infrastructure and products and services which will be more rigorously managed.

- As observed by the Auditor, MnDOT has recently expanded its inventory to include several additional asset classes beyond our historical datasets. MnDOT's new Transportation Asset Management System (TAMS) will house this additional data, and provide a system to capture costs and utilize the data for planning and management. As assets are evaluated and determined as good candidates for performance measurement and detailed tracking, those assets will be added to the TAMS system. As TAMS continues to mature, the opportunity to leverage additional maintenance asset data will be helpful for planning and budgeting for maintenance investments into the future.

- With the completion of asset inventories, the implementation of TAMS, and the development of performance measures and targets, MnDOT will have a complete maintenance management system. As noted in the report, this effort will improve MnDOT's planning, budgeting, and evaluation of its maintenance products and services.

- Also as recommended, an effort to estimate and understand user costs related to maintenance of assets will be made as a part of MnDOT's TAMP life cycle cost assessments. Depending on what is learned about the sensitivity of analysis to various assumptions, MnDOT may be able to alter recommended lifecycle maintenance practice schedules. MnDOT will also consider whether learnings from this effort could be reasonably applied to other products and services and consider further evaluation. Once appropriate user costs are identified, those user costs can be incorporated into the life-cycle costing models in TAMP. The completion of these activities is expected in approximately one more year.

- Regarding the maintenance funding distribution formula, MnDOT has begun reexamining the maintenance funding distribution formula. As a part of the evaluation, MnDOT will consider how to include cost effectiveness into the budget distribution formula, as well as a more rigorous correlation to infrastructure based needs. The formula review and revisions will be completed for use in fiscal year 2021.

Recommendation #14 MnDOT should explicitly evaluate the cost-effectiveness of new maintenance equipment and techniques. (Chapter 5)

- MnDOT agrees with the observations of the auditor that cost effectiveness could be a more significant factor when allocating funds for maintenance operations research.

- Many of the research projects funded directly by Office of Maintenance are relatively small in size and price. Projects focus on one particular task or piece of equipment with the intent to improve quality or reduce costs. They typically are done in-house, and result in a less formal research report as do other research programs operated by MnDOT. As such, the documentation for this program is not as robust. However, because the projects are smaller, costs and benefits are typically understood during the funding allocation decisions, even if not precisely documented.

- MnDOT will review this program, investigate analysis options, and implement cost-effectiveness evaluation techniques that are commensurate with size of the investments and the benefits being achieved.

Please accept my thanks for identifying these opportunities to improve the financial effectiveness of MnDOT's products and services.

Sincerely,

Margaret Anderson Kelliher, Commissioner
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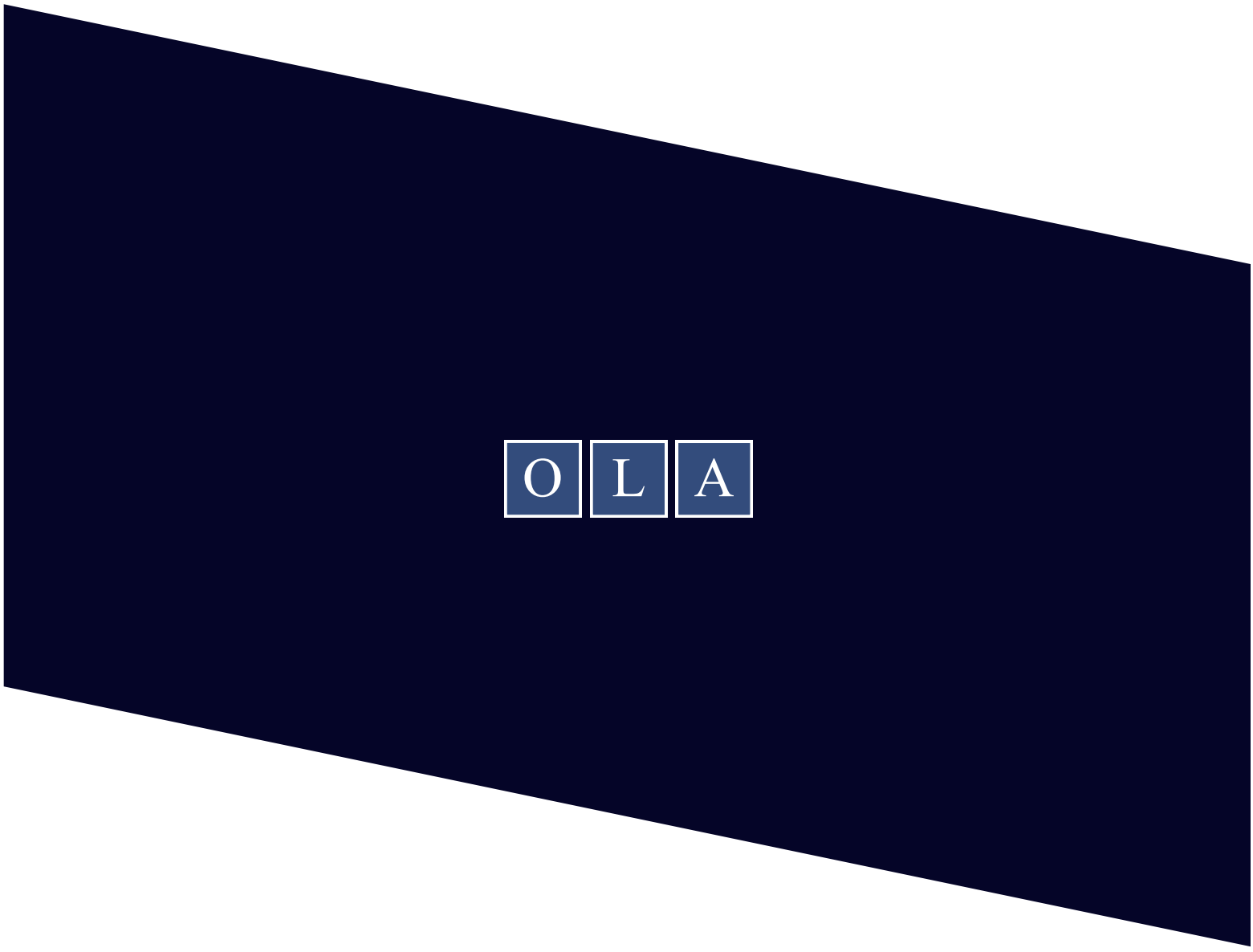

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