Economic and Development Implications of Transportation Disinvestment

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 480

Economic and Development Implications of Transportation Disinvestment

A Synthesis of Highway Practice

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FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

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PREFACE

By Jon M. Williams
Program Director
Transportation Research Board

As demand for transportation facilities outstrips our ability to provide new facilities or even maintain existing ones, decision makers are faced with hard choices. They must critically examine the most efficient use of transportation facilities and how to prepare for investment or disinvestment over time. This study focuses on macroeconomic effects, intermodal tradeoffs, and methods for broadly informing disinvestment decision making in an era of constrained resources.

The study examines methods available to estimate disinvestment effects on transportation system integrity within and across modes in urban areas, regionally, and in non-metro areas, and the use of those methods by transportation agencies. This includes economic forecasting and travel demand models, risk or probability models, needs models, and benefit and impact models.

Information for this report was gathered through a survey of state departments of transportation, a literature review, and interviews with transportation officials. Seven case examples illustrate different disinvestment scenarios.

Chandler Duncan and Glen Weisbrod, Economic Development Research Group, Inc., Boston, Massachusetts, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

ECONOMIC AND DEVELOPMENT IMPLICATIONS OF TRANSPORTATION DISINVESTMENT

SUMMARY

This synthesis addresses the economic implications of disinvestment (intentionally or unintentionally funding transportation facilities at levels below those required to maintain them in their current function) and focuses on ways that agencies can make decisions about disinvestment when funds are limited. As the 21st century progresses, it is becoming increasingly evident that it will not be possible to simply transition from an era of highway and bridge expansion to an era of preserving existing facilities as built. As America's highways, bridges, and other facilities age, geographic shifts change where the needs are the greatest; many of the nation's oldest and most costly facilities are serving geographic markets with dwindling population and employment. At the same time, the costs of preserving existing facilities prevent investment in new and growing areas that are currently underserved. These changes point to the need for a new paradigm of strategic investment in which decision makers consider not only the strategic use of transportation money to support new or existing assets, but also critically examine the most efficient use of transportation facilities and how to prepare for investment or disinvestment over time.

This report contains a literature review that summarizes prior research conducted on economic implications of disinvestment, underinvestment, and related decisions. It also assesses the ability of available models and tools to support strategic disinvestment scenarios through consideration of economic implications. In addition, the synthesis draws on a survey of state transportation officials and a series of case examples illustrating the current practices of some transportation agencies.

The current synthesis understands a disinvestment situation to be an instance where an agency, instead of simply tolerating underinvestment, makes a conscious choice to accept a lower performance standard or the use of an alternate facility in order to channel resources elsewhere. For this reason, this synthesis offers the following working definitions:

- **Disinvestment:** a process by which an infrastructure asset (which may be a specific facility, program, or network) is allowed to fall below previously accepted standards of condition or performance by either (1) investing resources elsewhere, or (2) simply not investing resources in the disinvested asset. This may also include choosing not to invest in new infrastructure or assets as needed to maintain an accepted level of performance on an existing facility or system.
- **Intentional disinvestment:** a conscious policy choice to disinvest in an infrastructure asset in order to make funds available elsewhere or to manage funding shortfalls.
- **Passive disinvestment:** a policy choice (or series of policy choices) that while not intended to allow an infrastructure asset to fall below previously accepted standards of condition or performance has just such an effect over time.

The literature review of this synthesis found a robust amount of literature on the process and implications of disinvestment in transportation systems. Available literature addresses several factors contributing to the need for highway disinvestment, including:

- Shifts in who uses infrastructure and how,
- Aging infrastructure,

- Fiscal constraints on agencies responsible for infrastructure, and
- Climate change and its associated risks to infrastructure.

Literature on how investing below target levels affects the economy includes studies on the costs of congestion, environmental damage, and safety risks to individuals and businesses using the transportation system. Literature on "underinvestment" also addresses the life-cycle costs associated with allowing transportation facilities to deteriorate in such a way that makes the inevitable improvements more costly when they do finally occur. The literature on links between investment and system performance includes models that explore how deteriorating transportation conditions impose costs on households and businesses, and how households and businesses respond to those costs in ways that affect the overall economy. The literature also documents how overall levels of investment in highways and bridges relate to the resiliency of transportation systems to perform in the face of unexpected interruptions or deficiencies.

A review of models used to assess transportation disinvestment scenarios was undertaken. Working from left to right, Figure 1 shows how and when different types of models are used. Assumptions about future socio-economic conditions are applied to generate economic and traffic forecasts. *Risk or probability models* provide an understanding of how likely these traffic levels are to occur. *Needs models* are then applied to decide what type of transportation facilities will be required to carry this future traffic. Finally, *benefit and impact models* assess how much money households and businesses can save from having the right transportation facilities in place and how much more productive the economy can be than if the facilities had been inadequate. In each of these models, assumptions about system capacity, acceptable transportation conditions, and the costs (or savings) associated with time, mileage, crashes, and other outcomes shape how the effects of investment or disinvestment are treated.

A review of available literature and models shows that there are ways for public agencies to anticipate and prepare for disinvestment situations; however, this synthesis demonstrates that states do not always utilize or synthesize the methods shown in Figure 1.

Through a series of case examples informed by interviews with officials from Minnesota, South Carolina, the Northeast Region of the National Park Service (NPS), South Dakota, Connecticut, Mississippi, and Washington State, this synthesis demonstrates how agencies approach disinvestment situations and their outcomes. The case examples show that, quite often, disinvestment situations are triggered by budgetary constraints (as found in the examples of Minnesota, South Carolina, NPS, Mississippi, and Washington State). In a few cases,

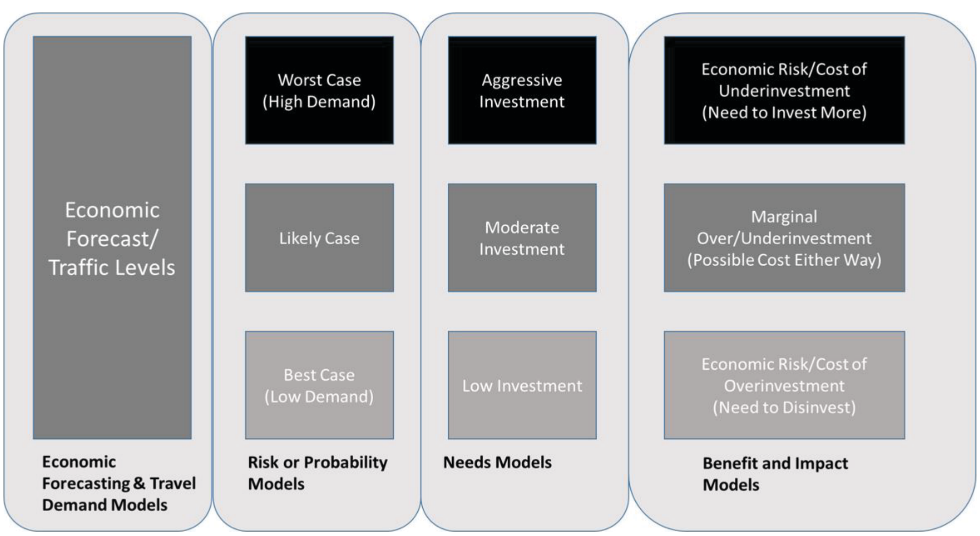


FIGURE 1 Role of different model types in disinvestment scenarios.

disinvestment situations are associated with changing traffic profiles and desired travel conditions (as found in the case examples of South Dakota and Connecticut). In several cases, agency staff indicated that their investment and disinvestment strategies were partially or fully dictated by higher level policy decisions, either at the state or federal level. Furthermore, multiple agencies expressed reservations about conducting economic analysis, given the level of effort, because they were unsure whether the added information would actually change the selected disinvestment strategies. Nevertheless, most agency staff consulted in the case examples viewed economic analysis as important to their ability to communicate the implications of disinvestment situations to the public, legislators, and policymakers. Across the case examples, understanding system-level performance was viewed as an important precondition to making strategic disinvestment and investment decisions. Case studies of previous projects and input from industry stakeholders were generally viewed by agency staff as a useful approach to understanding the economic implications of disinvestment.

The case examples in this synthesis contain valuable information about how agencies around the United States approach disinvestment situations. The Minnesota DOT case example highlights how the long timelines of negative transportation consequences of disinvestment can make it challenging to predict economic impacts with a reasonable amount of certainty. South Carolina and Mississippi DOTs both point to the challenges faced by agencies seeking to understand the economic tradeoffs between investments in preserving existing facilities and investing in new capacity in developing areas. The case example from the NPS emphasizes that disinvestment can be a costly process, even if it achieves long-term savings in operations and maintenance. South Dakota DOT's rail rehabilitation case demonstrates how investment and disinvestment may occur cyclically over time to respond to changes in transportation patterns. The I-84 project in Connecticut shows how, even for a single highway, designs can be changed to shift emphasis between different aspects of desired transportation conditions. The Washington State DOT case example clearly paints a picture of how decisions to overinvest in one part of a system (even passive or unintentional decisions) can result in passive disinvestment elsewhere, because of limited funding.

The implications of disinvestment situations for transportation conditions are a recurring theme in all the case examples. They also consistently identify a link between a decision to disinvest in a facility and the associated decision to invest in other facilities. Many of the case examples explicitly considered the risk associated with making transportation investment choices when uncertain about future traffic levels, the actual condition of existing facilities, and potential changes in financial, policy, economic, and political realities.

In addition to the literature review and case examples, a survey of state agencies was conducted in March and April 2014. Surveys were completed online or by telephone. Forty-one of the 50 state DOTs plus the District of Columbia and Puerto Rico replied to the survey. Based on the survey data, it was determined that states were divided evenly in terms of those that had made an intentional disinvestment choice in the last five years and those that had not. Among those agencies that did contend with disinvestment situations, most (70%) tended to face choices regarding disinvestment in entire programs or classes of roads. Among agencies facing disinvestment situations, another 50% faced a choice about disinvesting in a specific corridor or facility. Agencies did not appear to face disinvestment situations often at the corridor or sub-area level. The five-year process of developing a state transportation improvement program (list of funded projects) was by far the most likely circumstance for disinvestment situations, with 55% of respondents indicating these processes as the context of a disinvestment situation.

Survey respondents indicated that, unlike new construction or other types of analysis, disinvestment is often more of an internal than a public process. The most common responses indicated that most of the scrutiny on the disinvestment process was internal to the agency, with only some degree of external scrutiny. Most of the respondents (75%) who had faced disinvestment situations had engaged in some type of process to ascertain likely economic outcomes. However, the type of analysis varied from simply talking to businesses to engaging in formal impact modeling. When asked to assess the desirability of the analysis methods, respondents expressed a desire for more rigorous analytical approaches. Ultimately, the reasons agencies do not conduct economic analysis (for those that did not) reflect pragmatic considerations (limited budget to conduct analysis), combined with some skepticism as to whether the analysis would not have affected decisions.

In conclusion, key ongoing trends in infrastructure conditions, fuel technologies, changing demographics, and climate change are all driving the need for agencies to confront disinvestment decision making. Combining the results of the case examples, literature review, and survey yields insight into how and when agencies can most effectively address disinvestment situations. Taken together, the findings suggest that discussions about disinvestment are best informed by identifying the causes and consequences of underinvestment and progressing to a more strategic and deliberate approach. The literature on disinvestment decision making emphasizes the importance of defining the role of each transportation facility in supporting long-term system performance under changing conditions. The findings from the case examples and survey suggest a need to expand existing approaches of needs-based planning to account for risk and uncertainty in order to adequately support disinvestment decision making. Both the case examples and the survey show that many states are only beginning to proactively consider disinvestment as a meaningful choice in their planning, programming, and systems evaluations—and economic analysis of such scenarios is in its infancy. Furthermore, it is apparent that traditional techniques are underutilized when agencies confront a disinvestment scenario. However, there are promising approaches and practical steps that agencies can take to better understand disinvestment options.

This synthesis suggests that future research be conducted to:

1. Demonstrate how current performance and economic models and tools can be structured to assess disinvestment scenarios in ways that identify opportunities associated with resource constraints.
2. Provide a "teaching case" to enable transportation agencies to build a greater capacity to consider disinvestment and its economic implications in both their long-range planning and ongoing programming decisions.
3. Better pinpoint specific innovations and data requirements that could make disinvestment analysis more practical and useful to practitioners.

CHAPTER ONE

INTRODUCTION

Federal, state, and local governments are continually confronting the reality of deciding which elements of the nation's transportation infrastructure network will be triaged as maintenance and investment budgets shrink and cuts must be made. Fundamentally, decision makers understand that a suboptimally maintained transportation system can have adverse economic consequences. Likewise, there is broad recognition that efficiently moving people and goods improves quality of life, reduces travel costs, sustains economic growth (through improved accessibility to jobs and reduced costs to firms), and reduces the negative environmental impacts of travel (U.S. Department of the Treasury 2012; Rodrigue 2013b). And yet, that recognition alone does not mean that these impacts are being systematically evaluated and used in current decision-making processes.

This synthesis examines the current state of research and practice on these issues. It specifically focuses on macroeconomic effects, intermodal tradeoffs, and methods for broadly informing federal, state, and regional disinvestment decision making in an era of constrained resources. Disinvestment in a transportation facility or program is always a relative term. At the outset, any "disinvestment" situation presumes that an agency is truly invested in an asset or its performance. For this reason, this synthesis addresses how agencies come to be "invested" as part of the basis for understanding the implications of "disinvestment." Disinvestment may represent a level of investment either (1) below that which would be required to achieve a future projected needs target, or (2) insufficient to maintain an asset at its current level of condition or performance. Because most investment decisions are long term, seeking to address future needs, the emphasis in the current study is on the prior more than the latter, although this study considers both types. Also, it is notable that transportation disinvestment occurs at county and municipal levels; however, these situations often go undocumented in the literature and occur outside of formal planning processes and are, hence, largely beyond the focus of the current synthesis.

There are several practical examples of disinvestment situations. One example would be the decisions made after Hurricane Katrina not to rebuild damaged facilities to previous standards (whether the result of changed needs or to optimize scarce resources). In some cases, paved roads are allowed to return to granular surfaces. Other examples may include policy decisions not to build or rebuild facilities in areas that may be flooded or where such systems and facilities simply cannot be expected to perform or retain an intended condition given foreseeable revenue streams. By contrast, disinvestment is understood not to characterize situations such as the Alaskan Way Viaduct in Seattle (where old infrastructure is simply being abandoned and replaced with new infrastructure) or the San Francisco Embarcadero Freeway (where a facility is not replaced because the community concludes that a better and higher use of space can be achieved). The major characteristic of disinvestment, as defined in the current synthesis, is the objective of reducing the long-term investment levels in an asset and accepting the conditions and performance implications of this change.

One hope of the current synthesis is that it will raise awareness of disinvestment situations such that agencies can (1) recognize the situations as they occur, and (2) make decisions to realize potential opportunities associated with such situations. For example, if decision makers are aware of a disinvestment situation, related investments, policies, and practices may be oriented to mitigate adverse economic implications. In this way, agencies may use economic analysis to make the most efficient and highest use of the remaining asset as well as whatever scarce resources can be invested to meet the need previously covered by the disinvested asset, system, or program.

Although many plans and studies identify investment needs and economic costs associated with leaving needs unmet (see chapter two: "Studies of Underinvestment and Its Consequences"), the findings of such studies are almost entirely dependent on the magnitude of the needs estimate. Realistically addressing the economic implications depends primarily on the ability to identify the linkage between unmet needs, transportation performance outcomes, and economic performance. For this reason, the current synthesis resists the temptation to summarize and compare different needs studies (and the economic outcomes they would suggest) and instead places its emphasis on the state of the practice for applying and using economic methods to arrive at a responsible understanding of the economic outcomes likely to result from a transportation investment or disinvestment scenario.

The critical deferred needs of state and local transportation systems have been well documented (AASHTO 2010; ASCE 2011). Although the economic impacts of investing in transportation systems have been extensively studied and generally found to be positive (FHWA 2012b), the impacts of disinvestment have not been widely studied. There are several reasons for this.

Given the complex interplay of transportation systems within and between metro and non-metro economies it is sometimes difficult to determine how disinvestment affects linkages to key nodal points and capacities of different facets of the transport system. Therefore, it can be difficult to assess disinvestment impacts on national and regional economic growth, the distribution of income, and social and environmental sustainability. Moreover, it is not always clear how currently used transportation analytical techniques can be applied to ascertain the economic effects of disinvestment. By addressing these issues in an era of constrained resources, decision makers can be expected to benefit from new perspectives that establish the degree to which disinvestment outcomes will have implications for economic growth, business formation, and job creation.

It is understood that the performance implications of a disinvestment scenario are expected to affect key economic drivers including:

1. **Direct transportation impacts.** Disinvestment can lead to speed slowdowns; road, bridge, or viaduct closures; or vehicle size and/or weight restrictions, all of which can lead to changes in traffic volumes, speeds, and routings, which show up as vehicle-miles traveled (VMT) and vehicle-hours traveled (VHT) changes. Reductions in quality of pavement can also lead to changes in vehicle damage rates.
2. **Wider transportation impacts.** The direct transportation changes (see #1) can affect the set of available links, their volume and/or capacity ratios, and vehicle size or weight limits, all of which can lead to changes in reliability, accessibility, and intermodal connectivity.
3. **Direct economic impacts.** The direct and wider transportation impacts (#1 and #2) will translate into changes in business operating cost, business productivity (returns from deployment of vehicles, as well as effects on inventory levels), and household expenditure patterns.
4. **Wider economic impacts.** The direct economic impacts (#3) can lead to wider economic impacts on transportation and production efficiencies (through cost impacts), supply chain and logistics technologies (through reliability and intermodal connectivity impacts), and business agglomeration opportunities (through regional accessibility impacts).

This synthesis explores how the economic methods, tools, and techniques for assessing the following drivers have been or can be applied to disinvestment scenarios. Understanding how these mechanisms are affected in a disinvestment scenario it is necessary to understand the scenario itself and how its implications can be represented in economic terms. Consequently, the work performed for this study addresses the following topics:

- The need and economic role of analyzing disinvestment scenarios in the overall development and management of the transportation system.
- The applicability and sufficiency of economic models, data, and tools available for assessing the economic implications of disinvestment scenarios.
- Studies and practices that have examined or applied transportation disinvestment scenarios (actual or hypothetical).
- Lessons learned from case examples of the current state of the practice in economic analysis of disinvestment scenarios.
- A summary of current practices among transportation agencies seeking to understand the economic implications of disinvestment situations including:
  – The incidence and frequency with which agencies face disinvestment scenarios;
  – The levels of scrutiny and accountability requirements facing agencies when confronting disinvestment situations;
  – The degree of rigor in current economic methods and tools employed;
  – The confidence of practitioners in the economic methods and tools currently available; and
  – The greatest desires or unmet needs in the practitioner community pertaining to economic tools and methods for analyzing disinvestment outcomes.
- Potential research needs for additional methods, tools, or capacity building resources for agencies facing disinvestment situations.

Information has been gathered through a literature review and a survey of state transportation agencies to identify agencies that have assessed disinvestment scenarios. A survey of state practices was also conducted, relying primarily on members of the AASHTO Subcommittee on Transportation Finance Policy. This report also includes seven case examples of current practice at state departments of transportation (DOTs) and regional agencies.

BACKGROUND

Understanding the economics of transportation disinvestment entails understanding the disinvestment situation itself: how the situation occurs, how it is approached, and the associated frame of economic implications. The current state of the practice for assessing the economic implications of disinvestment in highway and bridge infrastructure is largely a function of changing long-term paradigms of infrastructure investment and asset management. Within this larger context, the current synthesis offers a framework for understanding the economic implications of disinvestment situations, and provides a working definition of disinvestment and an arrangement of related concepts. It also suggests a contemporary investment paradigm in which "disinvestment" can be analyzed and considered as part of an economic decision process.

Changing Paradigms

Expansion Paradigm 1956–1992

In the mid- to late-20th century, the United States completed the Interstate Highway System; auto ownership and VMT increased steadily (Litman 2014); and transportation agencies invested in new highway and bridge facilities to keep pace with the increasing role of vehicular travel in the United States (Lee 1982). During this era, residential, commercial, and industrial development patterns relied on new highway expansion to ensure connection of key trade centers, make additional land available for economic development, and accommodate the preferences of a growing driving population of people and businesses seeking moderate to low densities of development. The highway investment paradigm during this era is widely understood to have been one of highway expansion, where revenues available for capital investment in transportation were allocated to accommodate the increasing demand for new facilities in a growing economy.

Investments could be economically justified in market terms on the basis of the existing or emerging populations and economic activities served by new or expanded facilities. It was generally believed that as long as VMT kept pace with highway expansion, fuel tax revenues could keep pace with highway and bridge expansion and preservation requirements.

During this period, federal legislation created metropolitan planning organizations (MPOs), which began to model and forecast future travel demands based on socioeconomic projections (Solof 1998). Also during this period, the federal National Environmental Policy Act (NEPA 1970) began to require assessments of environmental implications of transportation investments, which included issues of the overall economic costs and benefits of investments (CEQ 2005).

During the expansion era, cost–benefit analysis generally would assume growing future demand, and compare a failure to expand the system to accommodate demand against a base case in which the system was not expanded. Very few agencies prior to 1992—the year in which the interstate system was completed (Row et al. 2004)—linked travel demand and performance models to economic impact models, as the economic analysis of long-term transportation economic impacts was still early in its early stages.

Asset Management Paradigm 1970–2014

Before the end of the expansion paradigm, the ongoing costs of maintaining and operating highway and bridge facilities began to place a strain on transportation revenues. Periodic costs of resurfacing and replacing assets, as well as annual operation and maintenance, continued to mount as the nation's highway and bridge system continued to expand and age. Agencies during this era began struggling to find the appropriate balance between investment to preserve existing assets in places where no expansion was required against the need to expand the system by adding capacity or new facilities (U.S.DOT 1999). During this time, there has been an increasing awareness of the life-cycle costs of expansion projects and growing concerns about the ability of revenue sources to both maintain today's assets and invest in those areas where demand continues to increase (FHWA 2004). The 2007 National Surface Transportation Policy and Revenue Commission study drew attention to the effects of increasing fuel economy, aging infrastructure, and other factors on the nation's ability to meet the investment needs of its transportation system. While economic impacts were not considered in their study, the Revenue Commission's work drew attention to the need to invest in maintaining transportation assets and the inabilities of existing revenue sources to keep pace with growing and changing investment needs.

Many states began to adopt the mantra of "fix it first" as a series of federal transportation laws from the 1991 ISTEA (Intermodal Surface Transportation Efficiency Act) to the 2012 MAP-21 (Moving Ahead for Progress in the 21st Century) placed a growing emphasis on the need to maintain existing assets for fear of losing the "sunk cost" (irrevocable cost) of long-standing investments. The role of cost–benefit analysis has increased as the FHWA has made tools and techniques available to state agencies for assessing both (1) the agency life-cycle costs of deferred maintenance, and (2) the economic user costs of deficient pavements and bridges (Cambridge Systematics 2005). The asset management paradigm has strongly impressed on transportation decision makers the reality that if an asset's conditions are allowed to deteriorate below certain levels, the cost of restoring that asset increases with each year the preservation need goes unmet. A growing body of research documents how deteriorating pavements and bridges affect the transit costs of goods, and the overall economic competitiveness of states, regions, and the nation as a whole (as further described in chapter two).

Just as the nation began to develop appropriate tools and methods for assessing the economic needs and implications of asset preservation and management, new changes have begun to challenge the "fix it first" asset management ethic. In the 21st century, there have been more fundamental changes in urban development and transportation patterns that have uncertain consequences for the future. Some cities have experienced a residential renaissance as the "millennial" generation has started migrating to their core central areas (McCahill and Spahr 2013). From 2007 to 2008, VMT actually declined across the United States as a whole, as a result of an economic downturn, with the steepest decline occurring in rural areas (FHWA 2008). However, traffic and congestion in many urban areas has continued to increase. Changes in settlement patterns were further exacerbated by the real estate and economic crisis of 2009, which significantly changed the rate of residential development in many U.S. cities from what it was projected to have been when transportation assets were originally built (U.S. Census Bureau 2014). Ongoing changes in housing preferences and urban land markets make it more difficult to predict transportation demands 20 and 30 years into the future (HUD 2003). As the 21st century progresses, it is becoming more evident that it will not be possible to simply transition from an era of highway and bridge expansion, to an era of preserving existing assets as built. As a consequence, the asset management era is beginning to give way to an era in which formerly invested and aging assets with growing preservation costs are serving declining demand in many areas, while at the same time other areas show needs for new investment in the absence of clear revenue streams to accommodate this change.

Strategic Investment Paradigm 2012+

The highway expansion and asset management paradigms have led the United States to the current situation where it is widely understood that agencies cannot simply "build their way out" of transportation performance challenges—such that building could overwhelm agencies in life-cycle costs. However, many state and regional transportation agencies have also arrived at a realization that simply "fixing it first" and "keeping what we have" can lead to ongoing investment in underutilized assets and underinvestment in changing demands.

Given these realizations, agencies (and federal legislation) are increasingly seeking to leverage performance metrics, economic and engineering data, and tools and technologies to support better investment decisions (Cambridge Systematics, Inc. et al. 2010). By combining the models used to assess needs for asset preservation, forecasting future traffic, assessing risk, and assessing economic benefits and impacts agencies are beginning to develop investment "recipes" that can economically optimize the use of transportation revenues in the long term. Although this paradigm is far from complete, the clear direction in transportation investment is toward a dynamic, performance-based approach.

The 2012 MAP-21 legislation introduced the concept of "performance-based planning" as a basis for using comprehensive data, tools, and systems to manage ongoing performance and investment tradeoffs in statewide and MPO transportation planning and programming. Economic methods, with their ability to monetize and compare performance outcomes for different investment "mixes" across performance areas are understood to play an important role in realizing this (see chapter two: "Needs-Based Planning and Quantifying the Effects of Unmet Needs by Program").

The new paradigm of strategic investment (supported by performance-based planning) recognizes that investment management must consider not only the strategic use of revenues to pay for new or existing assets, but also a critical examination of the most efficient use of assets themselves. For example, highways and bridges built in the 1950s and 1960s today serve very different populations than when they were built (see chapter two: "Demographic and Demand Shifts"). However, is it reasonable to expect (or to invest) in maintaining such assets to the standards for which they were *originally built*, or are there cases where it may be more economical to change the expected function and performance of assets?

The previous paradigms (expansion and asset management) primarily considered the economic implications of expanding—or at least maintaining—an asset in comparison to a future where the asset was not expanded or maintained (assuming the demand or need would be constant). However, the new paradigm entails considering the economic implications of reducing—or maintaining at a different function or performance standard—an asset that no longer needs to perform its previous function.

In confronting this new issue, there is risk that the existing methods, tools, and data may take an asymmetrical view of the economic implications of investments. For example, models, data, and tools have long been cultivated to identify and observe future needs over time, identify the costs of meeting those needs, and compare them with the economic costs of leaving such needs unmet. However, models, data, and tools have not been so well cultivated that they identify where needs are declining, and where disinvestment (or reductions in investment to support other needs) can be achieved with fewer adverse economic consequences. This is made even more complicated because of the asymmetry of benefits and costs associated with disinvestment (i.e., that small changes in investment cost can sometimes have much larger consequences for the usability of past investments).

Therefore, the new questions that arise include:

- What is the appropriate or economically efficient investment level for an asset or program?
- What is the economic risk of disinvestment to a lower than efficient level?
- What benefits might be foregone in a disinvestment situation or what benefits may accrue if disinvestment situations can be avoided or better managed?
- What are the economic costs of overinvestment in some assets to the neglect of others?
- Given that fully investing in all former and future assets is not feasible, what justifies a disinvestment choice?
- What are the risks of simply underinvesting without ever making a *disinvestment choice?*

This study synthesis explores the degree to which practitioner experiences and formal research have begun to address these questions.

Defining Disinvestment

For the purposes of this synthesis a distinction is made between simply underinvesting in an asset or system relative to a perceived need and actually disinvesting in existing assets or programs. Underinvestment (or deferred investment) has always been a relevant issue in fiscally constrained planning and programming. The economic implications of falling short of a needs target can generally be assessed by comparing a base case of "business as usual" investment levels (or a projected revenue stream) to a build case, where additional investments are made. The difference in transportation user costs between the base and build cases is generally understood as the basis of the economic benefit of investment (or cost of under or disinvestment). Once the agency understands these cost differentials, they can apply using widely accepted economic impact models (such as REMI or TREDIS) to derive wider economic impacts on local earnings, output, gross domestic product (GDP), and employment.

However, the current synthesis defines disinvestment as an instance where an agency, instead of simply tolerating underinvestment, makes a conscious choice to accept a lower performance standard or use of an alternate asset in order to channel life-cycle costs elsewhere. For this reason, the current synthesis offers the following working definitions of disinvestment:

- **Disinvestment:** a process by which an infrastructure asset (which may be a specific facility, program or network) is allowed to fall below previously accepted standards of condition or performance by either investing resources elsewhere or simply not investing resources in the disinvested asset. This may also include choosing not to invest in new infrastructure or assets as needed to maintain an accepted level of performance on an existing facility or system.
- **Intentional disinvestment:** a conscious policy choice to disinvest in an infrastructure asset in order to make funds available elsewhere or to manage funding shortfalls.
- **Passive disinvestment:** a policy choice (or series of policy choices) that, while not intended to allow an infrastructure asset to fall below previously accepted standards of condition or performance, effectively has such an effect over time.

Because it is understood that disinvestment can be unintentional (such as when a choice is made to forego investments at a particular time, while still recognizing the unresolved and unmet need), the following chapters will include a review of conscious underinvestment as examples of passive disinvestment.

Related Concepts

Because disinvestment can only be defined in relation to a particular target asset condition, performance, or investment level it is important to the understanding of how disinvestment relates to other concepts in performance-based planning. Chapter two explores multiple definitions and concepts related to disinvestment. First, however, the following definitions are offered by way of introduction to broadly capture the framework within which the economics of disinvestment are understood:

Economic development is the process by which a state, regional, or local economy's use of human, natural, and other resources evolves to create a given standard of living and effective role within the larger economy.

Minimum tolerable conditions is an asset management term used to describe the condition or performance below which an asset is considered to be "deficient" and needing additional investment to perform properly. These usually consist of pavement conditions, bridge ratings, volume-to-capacity ratios, or intersection level of service. Intentional disinvestment lowers minimum tolerable conditions to reduce the needed investment level.

Investment gap is the dollar amount that would have to be invested above and beyond currently budgeted amounts to achieve minimum tolerable conditions for all assets over a period of time. Intentional disinvestment reduces an investment gap by lowering minimum tolerable conditions, whereas passive disinvestment allows the gap to grow while still holding an intention to somehow "catch up."

Underinvestment is any revenue or budgetary policy that allows some investment gap in any given year for any given reason. Underinvestment over time may become passive disinvestment if conditions deteriorate so much that the agency could never afford to catch up or achieve its desired performance levels.

Programmatic investment strategy is a planning strategy that considers different possible revenue allocations among programs to minimize the adverse economic implications of investment gaps in various programs. A programmatic investment strategy may also compare the economic implications of additional taxes, tolls, or user fees against the economic implications of investment gaps in transportation programs. Disinvestment scenarios may have a role in a programmatic investment strategy.

Base case in an economic analysis is the scenario that assumes there is no change from the current investment pattern.

Investment (or disinvestment) case in an economic analysis is the scenario that assumes some change from the current investment pattern. In the case of intentional disinvestment, it may represent a change in performance standard for a given program or asset, the transition of demand to an alternate facility, or the costs and economic outcomes anticipated from retrofitting the disinvested asset for some other use.

Adaptive re-use is a tactic of redesigning or redesignating a piece of infrastructure formerly used for one purpose so that it can be used for a different purpose (at a lower cost). The Rails to Trails re-use of railroad right-of-way is an example of this. Adaptive re-use may be a source of benefits in a disinvestment situation.

Jurisdictional turnback is a tactic of a federal or state agency giving an asset to a county or municipal unit of government, making it effectively no longer a part of the state or federal transportation system. A turnback is often understood as assigning ownership and financial responsibility for a facility to an entity more directly representing its users. Although a turnback is not always a form of disinvestment (it may simply change the investing agencies), turnbacks can lead to disinvestment when they are accompanied by changes in classification or intended use for a facility.

Abandonment is the act of relinquishing an asset entirely and regarding the infrastructure investment as a "sunk cost" with the possible exception of the salvage value of the land.

STUDY APPROACH

The current synthesis of economic approaches to understanding transportation disinvestment draws on information from: (1) formal published literature, (2) case-based examples from the real world practice of transportation agencies, and (3) a descriptive survey of state transportation officials. For the purposes of this synthesis, the scope is limited to highway and bridge disinvestment in the United States, although relevant examples from other modes, nations, and industries are considered as they relate to U.S. highway and bridge disinvestment situations. The findings of each of these lines of inquiry are interpreted within the context of the background and context presented previously, with the synthesis concluding with suggested best practices and areas of future research on the economics of highway and bridge disinvestment.

CHAPTER TWO

REVIEW OF CURRENT RESEARCH AND PRACTICE

This chapter summarizes both the literature review and the review of models and data, their findings, and their relevance to the overall research.

LITERATURE ON DISINVESTMENT

Factors Necessitating Disinvestment Analysis

There are a number of factors that make disinvestment decision making particularly salient to transportation managers—now and in the foreseeable future. These factors include demographic shifts, travel demand trends, the aging of transportation infrastructure, fiscal constraints, the time horizon of analyses, data constraints, and environmental risk factors.

Demographic and Demand Shifts

From 1970 through the 2008 economic recession, transportation infrastructure has been subject to ever-increasing demand in terms of the VMT on the system. More recently, overall VMT has leveled off in a way that appears to be more than just a short-term trend (Figure 2)—leading to discussions of "Post Peak" transportation planning (Polzin and Chu 2014). Nevertheless, much of the highway system is subject to far greater demand than that for which it was initially designed. For example, the section of I-84 that runs through Hartford, Connecticut, is subject to a daily volume that is more than three times its originally designed capacity (Connecticut DOT 2014a). Moreover, trends such as increasing truck movements on particular subsets of the road network, geographically differential population growth, and increased urbanization mean that transportation demand may see increasing concentration in certain areas (and thus increased congestion) even as demand may level off or decrease in other areas (U.S. Government Accountability Office 2008). At the same time, mobility preferences among young people and aging retirees are associated with shifts toward shorter trips and nonautomobile travel (McCahill and Spahr 2013). Consequently, the transportation system in the United States is faced with significant and yet uncertain shifts in demand patterns, with behavioral and economic changes that may merit reconsideration of the optimal mix of transportation investments. Rather than focusing on a relatively uniform expansion paradigm, demographic and travel demand shifts point to a strategic investment paradigm that places emphasis on efficiently adapting existing or new assets to changing needs over time.

Aging Infrastructure

Aging infrastructure is broadly identified as a challenge for transportation infrastructure management in the United States (Knowledge@Wharton 2010; AECOM 2011; Transportation for America 2013; U.S. Government Accountability Office 2013). About 75% of the Interstate Highway System is more than 25 years old (Rodrigue 2013a); in some states the majority of the road infrastructure is significantly older than that (Figure 3). A 2010 study on the costs of underinvestment and the pressures of growth by AASHTO noted the need for reconstruction and replacement of aging interstate highway infrastructure simply to maintain the same performance levels as before, let alone offer more capacity (AASHTO 2010). Compounding the physical deterioration of assets is the concept that older infrastructure may not meet current performance standards. For example, many older interchanges do not comply with current operational standards and therefore create bottlenecks and safety problems (FHWA 2013).

Fiscal Constraints

Fiscal constraints at the national and state level are increasing the incidences of both intentional and passive disinvestment decision making. Fuel taxes, the long-time foundation of transportation funding in the United States, are no longer keeping pace with the requirements for system upkeep. Decreased buying power resulting from inflation, reduced VMT, and increased vehicle efficiency have contributed to a crisis in transportation funding (Puentes and Prince 2003). Based on current spending and revenue trends, U.S.DOT estimates that the Highway Account of the Highway Trust Fund will encounter a shortfall before the end of fiscal year (FY) 2014 (Figure 4). State DOTs are faced with both short-term cash-flow issues resulting from an anticipated slowdown in federal reimbursements and long-term fiscal constraints and funding stream uncertainty because of the considerable political difficulty associated with reforming transportation finance, both at the federal and state level.

Climate Change and the Convergence of Risk Factors

Yet another issue of prominence in the transportation planning sphere is climate change and its relationship to risk management. MAP-21 established requirements for a new Risk-based Asset Management Plan to be completed by each state. The

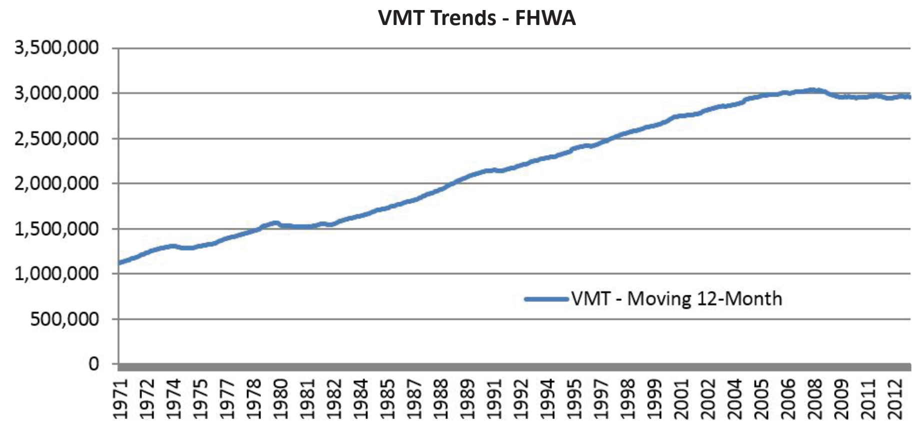


FIGURE 2 Trends in vehicle-miles of travel.

plan is to include an assessment of road and bridge assets and their condition, definitions of management objectives and measures, identification of performance gaps, analysis of life-cycle costs and risk, and a financial plan and investment strategies (AASHTO 2012). According to FHWA, "Climate change is one of multiple risks that impact asset management" (FHWA 2014).

Risks associated with climate change include accelerated asset deterioration from increased variation in temperature, precipitation, flooding, and other severe weather events (Meyer et al. 2010; Strategic Foresight Initiative 2011). In addition, the increasingly understood necessity for resilience planning may begin to put a strain on already limited resources (FHWA 2014). The convergence of multiple risk factors means increased pressure on certain critical infrastructure such as transportation (along with other infrastructure such as water and energy utility networks). Research conducted for the Strategic Foresight Initiative, a collaborative effort of the emergency management community being facilitated by FEMA, highlighted the existence of compounding effects for cities resulting from the convergence of climate change, aging infrastructure, and increasing urbanization of populations, particularly in high-risk coastal areas (FHWA 2014). Similarly, the World Economic Forum's 2013 Global Risk Assessment identified the interplay between constrained government resources, rapid urbanization, economic instability, climate change risk, and infrastructure needs as an important risk factor globally (World Economic Forum 2013). In a dissertation examining resilience strategies for critical civil infrastructure systems, Croope framed the issues as follows:

> Infrastructure systems are critical for sustaining and maintaining a nation's socioeconomic system. Their importance is underscored by the need to maintain continuity of services. . . . The functionality of critical infrastructure systems is continually challenged by the aging process, disasters (both natural and technological), and constrained resources (Croope 2010).

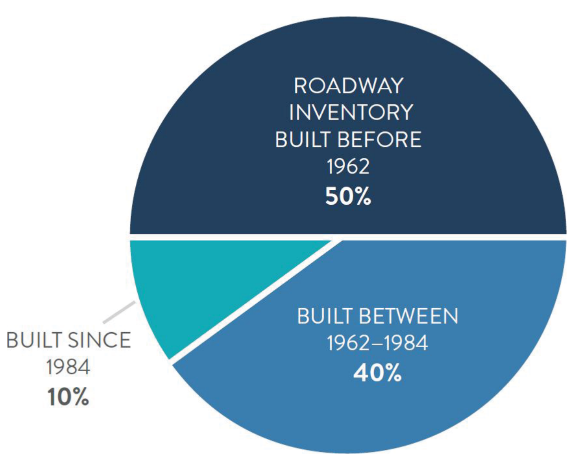


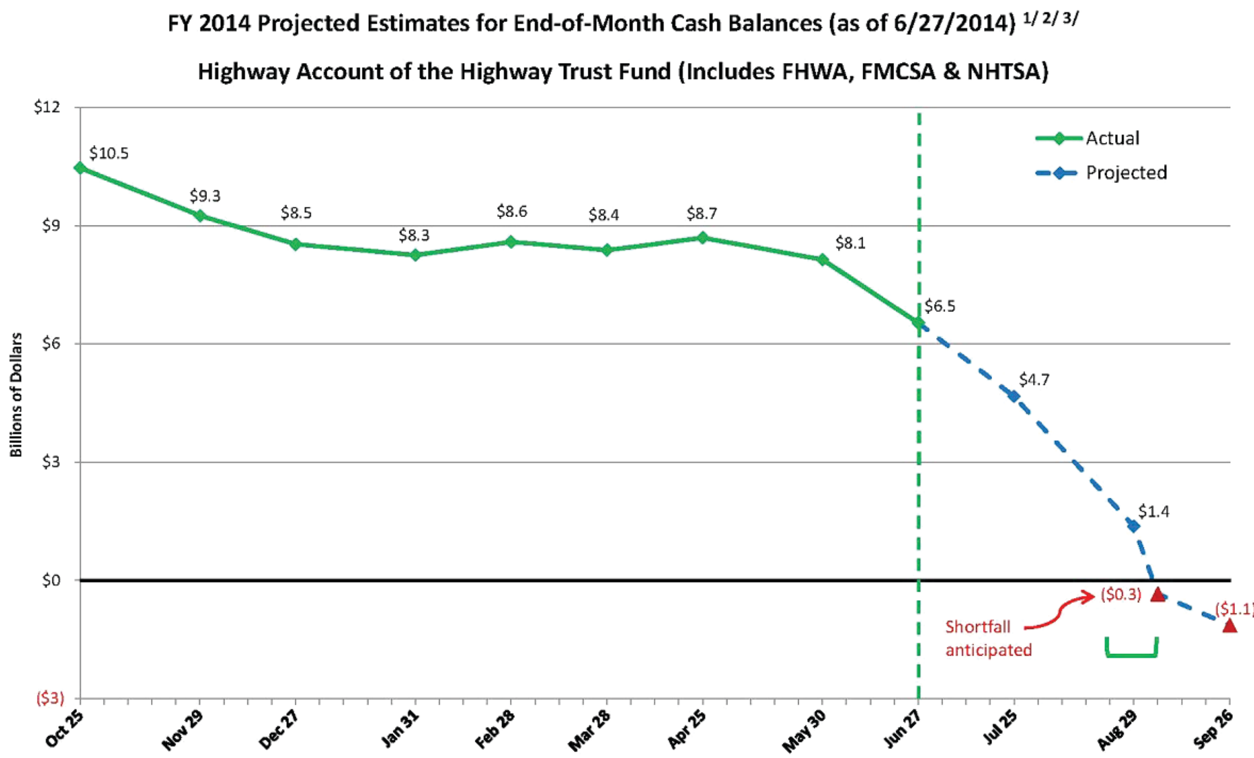
FIGURE 3 Age of the Connecticut Highway Network.

The combined influence of demographic and demand shifts, the aging of transportation infrastructure, fiscal constraints, and environmental risk factors means that decision makers are increasingly faced with difficult choices regarding the most effective mix of investments, given limited funding and changing performance requirements.

Studies of Underinvestment and Its Consequences

In the literature, the concept of disinvestment appears in a fairly broad range of contexts and is described with varying terminology. For many, the conversation on disinvestment begins with an identification of *underinvestment* and its negative economic consequences and underlying causes. While the issue is globally relevant, awareness of it is particularly strong in the United States and Canada. North American respondents to the World Economic Forum's survey on global risks were inclined to rate the risks of *chronic fiscal imbalances* and *prolonged infrastructure neglect* as having a higher likelihood of occurring over the next 10 years than respondents in other regions (World Economic Forum 2013).

Andrijcic et al. (2013) discusses the deterioration of transportation infrastructure in the United States as a slow, ongoing process whose socioeconomic implications are becoming increasingly apparent, including "increased economic costs



1/ Graph reflects actual data through 6/27/14 and end-of-month projections for the remainder of the fiscal year.

2/ Total receipt and outlay projections are based on FY 2015 Mid-Session Review assumptions. Projected monthly receipt and outlay rates are based on historic averages.

3/ Range of anticipated shortfall: Green brackets denote the estimated window of when the anticipated shortfall will occur.

Source: FHWA

FIGURE 4 Highway Trust Fund ticker, U.S.DOT.

of freight congestion, decreased global competitiveness of the United States, increased travel costs, and reduced safety of travelers." The authors also note characteristics of the U.S. policymaking process that tends to discourage the type of long-term investment required for system upkeep, such as the shortness of election cycles, the relative invisibility of benefits from infrastructure investment, and general public misunderstanding of the benefits of proactive maintenance (Andrijcic et al. 2013).

The focus on risks to economic competitiveness is common among studies of underinvestment. A joint report by the Eno Center for Transportation and the Bipartisan Policy Center argues that the most dramatic effects of cutting federal funding for transportation (to levels that are in line with reduced revenues coming into the Highway Trust Fund) will be *economic*. The economic consequences will be derived from reduced accessibility—"to labor and jobs as well as markets, goods, and raw materials"—and from the decline of transportation system capacity, even as population continues to grow (Eno Center for Transportation and the Bipartisan Policy Center 2012). Similarly, in a white paper prepared for the American Council of Engineering Companies, AECOM warns that "The consequences of underinvestment in these vital systems are dire, affecting the United States' global standing as a leader in economic growth, productivity, competitiveness, capital inflow, job creation, sustainability, and lifestyle" (AECOM 2011). In a 2012 analysis of infrastructure investment, the U.S. Department of the Treasury and the Council of Economic Advisors state that "investments in infrastructure allow goods and services to be transported more quickly and at lower costs, resulting in both lower prices for consumers and increased profitability for firms," and argued that "American transportation infrastructure is not keeping pace with the needs of our economy" (U.S. Department of the Treasury 2012).

There are a number of perspectives on what constitutes underinvestment. Most broadly, underinvestment can be defined as investment levels that do not keep pace with overall growth. For example, Gillen (2012) identified an investment gap for British Columbia by looking at infrastructure and transportation spending as a percent of GDP over time and in comparison with other countries and provinces. Underinvestment can also be defined in terms of a gap between funding levels and what is required to prevent deterioration of an asset's physical condition. Stiff and Smetanin define an infrastructure gap as follows:

> In general, an infrastructure deficit is the amount of investment required to repair and maintain existing public infrastructure. This includes the immediate funding for required upgrades, and the future investment needed to maintain a minimal level of service. It does not include investment required to accommodate future growth (Stiff and Smetanin 2010).

Interestingly, the authors also note that a greater estimated return on public capital, relative to private capital, can also be a sign that public infrastructure capital and private capital are out of balance (Gillen 2012).

At a higher level of complexity, underinvestment may be defined according to certain performance standards applied at the asset, corridor, or system level. For example, congestion is a commonly cited performance category that suffers from underinvestment. AASHTO calculates an investment "backlog," which is defined as the amount of money it would take to bring highways and bridges to a state of good repair, both in terms of *condition* and *performance*, is 46% of AASHTO's 2008 estimated backlog as the result of capacity deficiencies (AASHTO 2010). The ASCE "Failure to Act" series similarly used an approach that accounts for both the effects of physical deterioration and performance deficiencies, such as congestion caused by inadequate capacity (ASCE 2011). "Deficiency" is defined as the degree to which roads and bridges drop below "minimum tolerable conditions" according to U.S.DOT standards. This is significantly different from ideal conditions such as "free-flow" (ASCE 2011).

The ASCE series traces the causal relationship from system condition, to performance, to user costs, and finally to economic impacts in terms of personal income and value added. The types of costs imposed by transportation deficiencies include:

- Increased operating costs for vehicles using parts of the system in poor condition;
- Costs from vehicle damage owing to deteriorated road surfaces;
- Costs of detours to avoid unusable or heavily congested areas;
- The added costs of more costly repairs that result from failing to maintain assets in good condition;
- Increased costs associated with the additional buffer time that must be added to trips made in congested areas to ensure on-time arrivals and delivery; and
- Increased environmental and safety costs from vehicles operating in substandard conditions (ASCE 2011).

Although the literature on underinvestment is instructive in terms of identifying issues and risk factors that need to be communicated in the political arena, where overall funding levels are set, it does not provide adequate decision-support for those faced with managing underinvestment or disinvestment decision making. Moving beyond the underinvestment focus, it is important to recognize that when faced with changing conditions, agencies need to be able to make the best informed decisions about both investment and disinvestment strategies.

Similar to those cited previously, Aultman-Hall et al. (2010) identified "a longstanding funding gap between identified needs and revenues available." However, they also go one step further to warn against the "even greater reduction in mobility" that will result from "haphazard disinvestment." The authors are particularly concerned about the consequences of the funding gap for rural areas and argue that rural America may need to lead the conversation on strategic disinvestment and tradeoffs because "rural areas presently lack the alternative infrastructure or built environment and land-use pattern to be able to strategically disinvest from portions of our roadway network" (Andrijcic et al. 2013). This highlights the importance of considering network performance across modes and geographic areas when seeking to understand the implications of different disinvestment strategies. According to Aultman-Hall et al. (2013), *strategic disinvestment* would entail a process for prioritization based on the "tradeoffs between maintenance, rehabilitation, expansion, and doing nothing."

Disinvestment in the Literature and Understanding System Performance

The word "disinvestment" itself appears in the literature in only a limited number of instances. Nevertheless, as early as 1982, researchers were highlighting the necessity for different types of management approaches as the U.S. highway system transitioned from a paradigm of expansion to a paradigm of maintenance, reconstruction, and in some cases disinvestment (Lee 1982). Lee argues that the data and methods required for this type of management paradigm are different from those required in an era of growing system mileage and capacity expansion. In particular, Lee presents a structure for understanding critical information needs for sound management practice, as shown in Figure 5:

- Arrow (1) represents the effect of improvements (e.g., "overlays, bridges, lanes, shoulders, medians, grading, tunneling, land acquisition, signing, signals, pavement markings, maintenance, repair, landscaping, and other construction and operating activities") on performance (e.g., the volume-to-capacity ratio or pavement condition);
- Arrow (2) represents the influence of use (volumes, vehicle types, vehicle weights, network distribution, etc.) on performance;
- Arrow (3) indicates the influence of performance on user costs (e.g., travel time, fuel consumption, vehicle wear, and safety cost); and
- Finally, arrow (4) captures the feedback between user costs and demand.

Lee noted that the transportation system can be characterized by certain concentrations of demand (e.g., by time of day, on certain parts of the network) and thus it is even more critical to understand performance in these areas, relative to others, rather than approaching the system from an aggregate or averaged perspective.

In setting up a framework that relates investment strategies to system performance and user costs, Lee also established a framework that can, in principle, be used to tradeoff

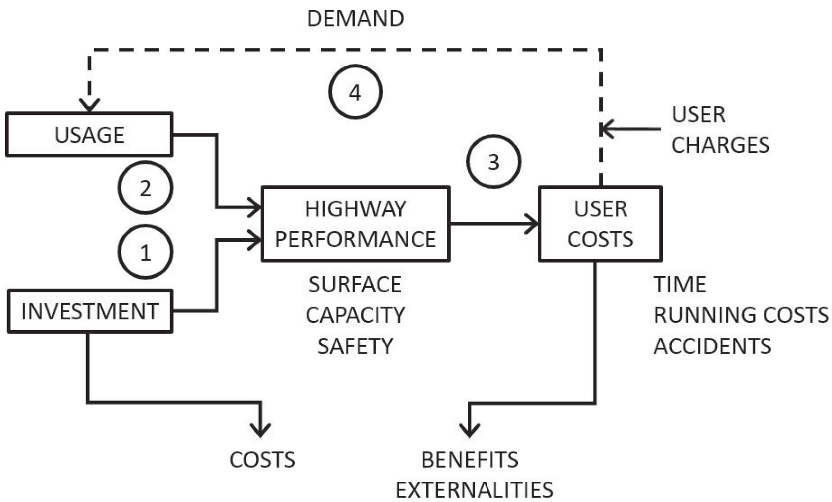


FIGURE 5 Functional relationships between highway costs and benefits.

different investment strategies against the costs imposed on users of the system. His understanding of investment included decisions made in setting design standards, noting that in some cases "the costs of overdesign may be just as great as the costs of under-design." Indeed, the lowering of performance standards to save on cost and (hopefully) more closely approximate actual needs—based on patterns of usage—is a special class of disinvestment situation most often seen in lower-traffic areas in order to redirect funds toward investments with higher returns (Peterson and Marais 1980; Ou 1986; Mercier 1987).

A 1998 World Bank report on road deterioration in developing countries addresses the investment-user-cost tradeoff more explicitly. The authors argue that when budgets are constrained, "the best policy is not simply to reduce all categories of maintenance spending equally" but rather to revise policies and use different maintenance approaches, based on a tradeoff analysis between agency costs and the value to users of different maintenance strategies (Harral 1988). Figure 6 presents one example of this type of approach. The line in Figure 6 is the efficiency frontier for a particular example situation, which shows the highest available value for any given level

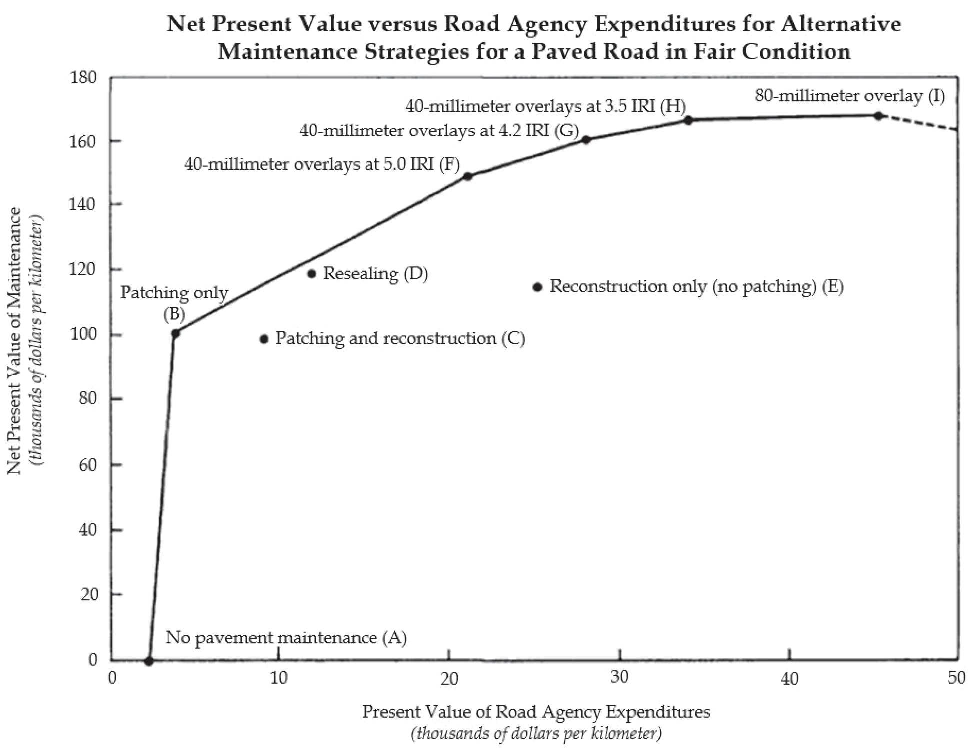


FIGURE 6 Example World Bank Analysis: Net Present Value of Alternate Maintenance Options Applied to a Specific Road Class.

of agency expenditure. Under an unlimited-fund scenario, the optimal strategy is indicated by point (I). As funds are reduced, an agency moves left along the frontier. The curve is initially flat, indicating the availability of budgetary savings without increasing costs to road users by a significant amount. After a certain point, however, the consequences of reduced funding become much more destructive. The report also addressed the time dimension of maintenance and deferred maintenance. It argues that, because reconstruction costs are three to five times as much as resurfacing or rehabilitation, no road should be allowed to deteriorate to a condition where it needs partial or full construction, unless it is to be held in that condition deliberately or abandoned: "The failure to maintain roads [is] tantamount to an act of disinvestment, for it implies the sacrifice of past investments in roads" (Peterson and Marais 1980).

Consideration of the time dimension of costs is formalized in life-cycle cost analysis. Novick urges the use of life-cycle considerations in infrastructure engineering, particularly to support strategic decision making in situations of constrained resources:

> The result of deferred maintenance is inevitably substantially higher ultimate life-cycle costs. Conversely and equally clearly, the degree to which any type of transportation facility is well maintained materially assists in providing better, safer operations with lower life-cycle costs. . . . Effective and timely maintenance . . . minimizes the magnitude and cost of repair and rehabilitation and defers ultimate reconstruction. In other words, effective and timely maintenance reduces life-cycle costs substantially (Novick 1990).

He warns that "funding concerns tend to mask an equally important requirement—the need to develop a rational basis for making far-reaching decisions about the required degree of rehabilitation or replacement" (Ou 1986). Novick identifies the need for methods to estimate and communicate: (1) realistic costs to the public of not having a particular piece of infrastructure available, (2) life-cycle costs, and (3) comparative costs of replacement, rehabilitation, reconstruction, and disinvestment.

The first of Novick's defined needs—developing estimates of the cost of not having a piece of infrastructure available—requires a systems-level approach to understanding performance. Limitations on performance for a given asset cannot be fully understood in isolation, but rather must be understood within the broader context of network performance, using analytical approaches that capture diversion within the transportation network.

For example, ongoing efforts at the University of Vermont Transportation Center have developed the Network Robustness Index (NRI) as a way to identify critical links within a transportation system and to understand performance effects of capacity disruptions (Novak 2010). The NRI (defined in Exhibit 1) is designed to assess the comparative robustness of transportation networks and to improve on localized measures such as volume-to-capacity ratios. It has been tested using a Vermont MPO travel demand model, where link-specific NRIs were used to identify the set of most critical network links. A follow-up work is underway to incorporate trip importance, by trip purpose, into the NRI framework, to support more strategic reinvestment and disinvestment decision making (Sullivan and Novak 2014).

Fruin and Halbach (1992) performed a network-based analysis of investment and disinvestment in a Minnesota

The NRI is the increase in total vehicle-hours of travel (VHTs) on the transportation network resulting from the disruption of a given link. Therefore, the index is link-specific. First, total VHTs when all links are present and operational in the network is calculated for the base-case scenario. The total VHTs are a system-wide, travel time cost:

$$c = \sum_{i \in I} t_i x_i$$

Where t_i is the travel time across link i, in minutes per trip, and x_i is the flow on link i at user equilibrium. I is the set of all links in the network. Second, the total VHTs after link a is removed or disrupted and system traffic has been re-assigned in the traffic assignment model to a new equilibrium, is found:

$$c_a = \sum_{i \in I/a} t_i^{(a)} x_i^{(a)}$$

Where $t_i^{(a)}$ is the new travel time across link i when link a has been removed or disrupted, and $x_i^{(a)}$ is the new flow on link i. Finally, the NRI of link a is calculated as the increase in total VHTs over the base case:

$$NRI_a = c_a - c$$

Therefore, the application of the NRI requires the specific definition of an analysis period for which an origin-destination demand matrix has been developed (Sullivan et al, 2009b).

Source: Sullivan, J., L. Aultman-Hall, and D. Novak, *Application of the Network Robustness Index to Identifying Critical Road-Network Links in Chittenden County, Vermont*, UVM TRC Report # 10-009, June 2010, pg. 3. [Online]. Available: http://www.uvm.edu/~transctr/trc_reports/UVM-TRC-10-009.pdf [accessed April 17, 2014.]

EXHIBIT 1 Method for calculating the NRI index.

county's rural road network. The potential for disinvestment arose because a declining number of farms and increased truck size were changing traffic patterns on the local road system. The authors conducted a tradeoff analysis comparing vehicle operating cost and time costs with road and bridge maintenance and upgrade costs—with modeling of future traffic on the network and a sensitivity test based on a less intensive crop production scenario (Fruin and Halbach 1992).

More conceptually, the World Economic Forum provides a framework designed to help assess system resilience to risk. Resilience is the ability of a system to accommodate, adapt, or recover when certain risks are realized (Mitchell and Harris 2012; McNeil 2013; World Economic Forum 2013). The framework defines five components of resilience; the first three describe system characteristics, the other two relate to resilience performance:

1. Robustness—the ability to absorb and withstand disturbances.
2. Redundancy—the ability to use excess capacity and back-up systems to maintain core functionality in the event of disturbances.
3. Resourcefulness—the ability to adapt and respond flexibly.
4. Response—the ability to mobilize quickly (depends on the capacity to gather information and translate that information into good decision making, in a timely fashion).
5. Recovery—the ability to regain a degree of normality after an event, and to evolve to deal with new or changed circumstances after the manifestation of a risk.

These components describe the characteristics of physical systems (e.g., transportation infrastructure itself) and of the people and organizations that manage and interact with the physical system. While generally understood in relation to events or incidents (e.g., natural disasters), some resilience concepts are instructive when considering more long-term disinvestment scenarios. In its recent literature review on Risk-Based Transportation Asset Management, U.S.DOT is careful to define risk broadly to include both "catastrophic failure of an asset" (generally thought of as an event) and the often more gradual or ongoing "failure to ensure desired levels of service" (Proctor and Varma 2012).

Finally, a recent study of two highway closures in St. Louis and Appalachia identifies transportation network and economic factors that can act as determinants of the economic impacts of lost system performance (Hodge 2011). The identified factors are also relevant to the impact of closures or restrictions associated with disinvestment and include:

- The availability of (and level of information about) alternative routes;
- The industry mix in area (how dependent business activity is on pass-by or discretionary visitor traffic);
- The mix of traffic (whether the closure affects mostly local trips or long-distance trips); and
- The development of mitigation strategies beforehand.

Needs-Based Planning and Quantifying the Effects of Unmet Needs by Program

"Needs-based" planning is a planning approach that entails deriving target investment levels based on "minimum tolerable conditions" of highway capacity, pavement condition, bridge condition, transit availability, and other performance indicators. A typical needs-based planning study will identify the size of the investment gap for each program and will use models to quantify the performance implications, agency life-cycle costs, and public-user costs of leaving needs unmet. An investment strategy that enables the agency to avoid the life-cycle or user costs of unmet needs is understood to have a benefit when compared with a base case, which fails to address such needs.

There is a significant body of research pertaining to economic analysis of declining transportation investment within the context of needs-based planning. Schroeder et al. (2012) offer a framework that begins by identifying freight infrastructure needs using widely accepted pavement and bridge models, and assesses the comparative economic impacts of unmet needs as the basis for prioritization (using input–output modeling). In 2011, the Arizona DOT completed a statewide plan that compared different investment options with a "business as usual" base case with unmet needs for various programs (Omer 2011). The Arizona plan presented economic benefits of different investment levels in terms of the avoided costs of unmet needs in the long term. In 2005, a similar plan in Michigan compared the user costs of unmet needs by program with different improvement cases, using the difference in user costs (and their associated economic impacts, in input–output terms) as the basis for quantifying economic impacts and benefits of additional investment (Wilbur Smith Associates 2005). Also in Michigan, a 2008 study analyzed the comparative impacts and benefits of shifting investment between highway and bridge preservation or expansion programs by assessing needs for each program based on "minimum tolerable" future conditions and comparing the relative benefits of investment in each area with a base case in which no investment was made (Fulton et al. 2008). Also in 2008, a Kansas study compared base case conditions (without investment) to future investment case conditions (accounting for changes in pavement condition as well as the associated changes in the routing of traffic) to ascertain economic benefits and impacts of investing to meet future needs compared with leaving needs unmet (Kansas DOT 2008). NCHRP Project 8-36 (67) presents an overview of investment strategies throughout the 50 states, focusing on key decision principles applied by states when considering the economic and performance tradeoffs of deciding which needs to meet or leave unmet (Janik 2007).

These examples are samples of the current state of the practice in state agencies where agencies assume future needs based on a current understanding of long-term demand, and characterize the economic benefits and impacts of the gap in terms of economic costs accruing to agencies, households, or businesses when such needs are left unmet. It can be noted that in all of the needs-based planning studies to date, needs are presumed to be set based on a singular understanding of future demand—and there has not generally been consideration of different levels of need that may arise from different possible socioeconomic futures. All of the needs-based planning scenarios assume a static understanding of future economic and demographic conditions and then focus on comparing different investment mixes for meeting the presumed needs of the future economic situation. However, as presented before, it is clear that the uncertainty of future economic conditions (and the likelihood of unmet needs under alternative future economic conditions) makes actual needs and actual risks of underinvestment or disinvestment more difficult to understand than the current practice assumes.

Learning from Other Disciplines

Although this project is focused specifically on highway and bridge disinvestment situations within the public sector regarding road and bridge assets, the type of decision and the generic structure of options available for consideration appear in other disciplines. Here we look briefly into approaches used within the private sector to support disinvestment-type decision making.

Corporate Divestiture—Insights from a Roundtable Discussion

PricewaterhouseCoopers hosted a roundtable of corporate business development executives in 2012 to discuss "strategies for managing a successful divestiture" (PricewaterhouseCoopers 2012). *Divestiture* refers to the decision by a company to sell off a portion of the company in order to focus more specifically on activities with higher growth potential or that are more central to an organization's core mission. Participants in the roundtable recommended a number of factors that could be considered when addressing this type of disinvestment situation. First, a particular activity or business line is ripe for consideration if it experiences "poor performances with declining market share and profitability." Translated into more general terms that also apply within the public sector, disinvestment would be considered if the market being served is no longer as relevant or as strong. Once poor performance has been identified, one must also ask: "why is this business underperforming, and is it worthwhile trying to fix the problem rather than divest?" In the transportation field, this points to the familiar process of developing alternatives and assessing their relative costs and benefits. Next, the recommendations highlight a key question that must be answered as part of the disinvestment assessment process: "How critical is this business to the rest of the organization. Do we fully understand the interdependencies and their impact on key stakeholders in the company (customers, suppliers, etc.)?" Performance cannot be considered in isolation. As with roads and bridges, there are network effects and system interdependencies. Lastly, the forum participants caution that disinvestment scenarios should consider the initial costs incurred in the process of disinvestment. Perspectives on disinvestment from the private sector are less complicated than public disinvestment choices because the effects that public infrastructure outcomes can have on the overall business environment for private firms.

Engineering Economics and Replacement Decisions

Disinvestment and investment decisions are closely related. In particular, disinvestment situations can come to light in the context of deciding how and/or whether to replace a given asset versus substituting another asset that would likely be used in its place. Given the age of much of the interstate highway system in the United States, large-scale replacement decisions are becoming an increasingly important type of decision for state DOTs. More broadly, replacement decisions are a common class of decision within engineering economics. It can be generally assumed that an existing asset will be removed at some future time—either when the function it performs is no longer necessary or when the function can be performed more efficiently by a newer and better design (Park 2011). To determine whether an asset should be replaced and what it should be replaced with requires a definition of operational performance requirements. In cases where an asset is deemed essential to operations (meaning that failure of the asset would result in an unacceptable slowdown or shutdown of operations), one must then answer the question "*when* should existing equipment be replaced with more efficient equipment?" (Park 2011). Embedded in this question is the understanding that no asset or piece of equipment lasts forever, that every replacement decision involves at least one alternative option for that equipment's replacement, and that timing is often a choice.

In cases where demand or performance requirements have not changed significantly since the assets initial selection and installation, the driving force motivating replacement is that operating costs nearly always increase as an asset ages. Keeping an asset (the "defender" in engineering economics parlance) usually involves a lower initial cost but higher annual operating costs (which include maintenance and repairs) relative to the replacement option, which costs more upfront but involves lower annual operating costs. Another common cost accounted for in engineering-type analyses is the salvage value of the asset, which is likely to decline over time. In a simple analysis of replacement, one simply compares the net present value of the future costs for the defender and challenger. In some cases, analyses will also take into account varying assumptions about technology changes in the future, thus recognizing that the type of performance available may not be the same a few years down the road as it is at the time of analysis.

Real Options and Flexibility in Decision Making

Another analytical construct that can be of relevance to the economics of highway and bridge disinvestment is the concept of a "real option" (Pindyck 2008). The concept of real options stems from financial options theory. "In finance, an option is defined as the right, but not the obligation, to buy or sell an asset under specified terms" (Zhao et al. 2004). The idea behind real options is that any "investment decision can be treated as the exercising of an option" (Pindyck 2008). Firms or agencies have the option to invest (or disinvest), but need not necessarily do so immediately. They can also wait until more information is available—about future conditions such as demand, prices, etc. If an investment involves a sunk cost, there can be considerable opportunity costs associated with investing now rather than waiting. Given future uncertainty, and the full or partial irreversibility of certain kinds of investment and disinvestment situations, a real-options framework adds more insight than a traditional analysis based on the net-present-value of a project's cash flow. Option theory encourages managers to consider options such as:

- the option to delay an investment,
- the option to stop before completion,
- the option to abandon after completion, and
- the option to temporarily cease operations.

In many cases, a certain amount of investment is required up front to purchase a "real option" that can be exercised at a later point in time. One chooses to make this initial option purchase if the cost is less than the *value of flexibility* provided by the real option. For example, one may choose to purchase a wider right-of-way for a project than needed for the initial number of lanes to be built, as a way of purchasing the option, but not the requirement, to expand in the future.

In general, the availability of an option to disinvest at a later point after initially investing, if demand proves inadequate or costs become too high, increases the net present value of a project under consideration. This is because managers know they will have the option to take advantage of future information to re-optimize their investment (or disinvestment) strategy at a point in time when uncertainty has been reduced. When a disinvestment option is available, managers become less cautious about their initial investment decision and they therefore tend to exercise their option to invest earlier (Keswani and Shackleton 2006). In the case of both investment and disinvestment, increasing uncertainty about future conditions could result in increasingly cautious behavior—favoring a wait-and-see attitude (Bloom et al. 2007). In practice, however, reluctance to disinvest can exceed that predicted by real-options theory, because of factors such as "emotional attachment" and "psychological inertia" (Musshoff et al. 2012).

A real-options framework may also be useful for more strategically addressing disinvestment situations. Often, there is a spectrum of available alternatives when considering disinvestment—some more severe or irreversible than others. Depending on the situation, it may be possible to opt for: (1) a gradual disinvestment scenario that is still irreversible, but can be suspended at any point; or (2) a partial disinvestment scenario that still maintains the option to restore full performance levels in the future, without incurring prohibitive costs to do so.

In the first case, managers must consider the tradeoff between:

- The flexibility offered by gradual divestment to benefit from possible future positive market developments, and
- The greater sale value of a whole firm, relative to the discounted value of partial displaced assets.

If a firm chooses gradual divestment, then "the firm holds a bundle of options to sell its partial assets. A marginal sale of assets leaves the options to sell the remaining assets and allows the firm to benefit from their optimal execution in the future" (Gryglewicz 2009).

In the second case, managers may choose to make an investment and/or invest in a certain minimum level of maintenance in order to at a later point have the option to restore service without starting over (and thus incurring the greater costs required to start from nothing). This kind of analysis has been commonly performed for power plants and other scalable business operations: the options available are shutdown, startup, and abandonment, and the key costs considered are called "switching costs," involved in switching from one operating state to another (Bakke and Viggen 2012).

One formalized example of purchasing a real option to enable future reactivation of a transportation service is the Railbanking program authorized by the National Trails System Act. It is "a voluntary agreement between a railroad company and a trail agency to use an out-of-service rail corridor as a trail until a railroad might need the corridor again for rail service. Because a railbanked corridor is not considered abandoned, it can be sold, leased, or donated to a trail manager without reverting to adjacent landowners" (Rails to Trails Conservancy 2014). Railbanking allows a private operator to temporarily cease rail operations, while still maintaining the option (at least in theory) to resume service at some future point of time without incurring the prohibitive costs associated with re-acquisition of land. It requires some level of initial investment to establish the agreement with the trail operating entity and to convert the land to its new use; however, this investment is less than both the cost to continue operating and the cost of reacquiring land at a later point in time when demand might be again adequate to justify service. Although the idea of railbanking falls neatly into a real-options framework, there are political and public perception switching costs associated with transportation infrastructure (even if owned privately) that can be particularly difficult to assess and account for because of the high visibility of these facilities. It is unclear whether a rail corridor, once converted to a public-use trail, will ever be switched back to an operating rail line. Such a switch would certainly require considerable political capital.

To summarize, a real-options framework can be useful when managers are faced with future uncertainty and have the ability to consider a spectrum of investment and disinvestment possibilities at various points in time. Managers may choose to wait until more information is available before making an investment or disinvestment choice. Real-options analysis provides a methodology for valuing the flexibility to "wait and see," and to compare this value with the investment needed to purchase that real option. Applying this valuation methodology to public infrastructure will require consideration of public agency, user (individual and corporate), and external costs associated with each investment and disinvestment option.

Applicability to Transportation Disinvestment Decision Making

There are a number of issues that make it difficult to transfer private-sector or engineering approaches to disinvestment situations to the context of public-sector transportation decision making. Most prominently, performance within the private sector tends to be better defined and subject to less uncertainty. Often, performance is reducible to the common denominator of dollars, viewed from a single corporate perspective with less concern about the incidence of specific costs across different groups (as in the case of transportation decisions that differentially impose costs and benefits on the federal government, state governments, and a diverse set of system users). Transportation operates within a broader socioeconomic context—making its performance both complex and open. It is therefore challenging to define performance targets or minimum tolerable conditions. Although those faced with more straightforward engineering systems may be able to easily define whether an asset is "essential" to system performance, those determinations are not so clear cut for transportation. The safety realm is perhaps the most well-defined. On the other hand, what does it mean for a piece of a transportation network to be economically essential?

Moreover, performance needs can be expected to change over time, both because of shifts in demand and technology, and because of the ever-evolving understanding within society of the aims of transportation. For example, our collective emphasis on environmental sustainability and on livability has changed considerably since the majority of the Interstate Highway System was built. As Zhao et al. (2004) point out, a highway system is subject to both internal and external uncertainties in the course of its life cycle, including "changing requirements of users in terms of traffic demand, changing social and economic environment, changes in technology, and deterioration of the highway." These uncertainties are interrelated; changing social and economic conditions influence demand, which in turn influences deterioration processes. Those deterioration processes can then in turn provide feedback and deter certain travelers, thus also affecting overall social and economic conditions.

The transferability of the issues described earlier will require scrutiny and consideration when developing methods to support strategic disinvestment. Nevertheless, there are core concepts from other disciplines that can help structure assessments of transportation disinvestment; namely, the need to acknowledge system interdependencies, an emphasis on life-cycle costs (which already appears quite extensively in transportation maintenance management), and the value of flexibility when dealing with future uncertainties.

MODELS AND DATA FOR ANALYZING DISINVESTMENT

Needs models, demand models, risk models, and impact models all play a role in understanding a transportation disinvestment scenario. In all cases, models require data about existing asset conditions, expected deterioration rates, current and projected employment, housing and other drivers of demand, and utilization, as well as per-mile and per-hour factors of user-cost resulting from different demand levels experiencing different conditions.

Needs Models

U.S.DOT and private vendors have developed models to enable agencies to assess highway and bridge investment needs. These models usually begin with: (1) a database inventory of existing asset conditions, demands, and factors (such as roadway functional system, climate, terrain, urban, or rural area types); (2) a set of default improvement costs; (3) a set of minimum tolerable future asset conditions; (4) a set of anticipated per-mile, per-vehicle, or per-hour user costs of falling below minimum tolerable conditions; and (5) a set of assumptions regarding future demand. Using these inputs, needs models assess: (1) the likely future investment needs, (2) the likely comparative user costs (in dollar terms) if needs are unmet, and (3) the likely agency life-cycle costs (in dollar terms) if needs cannot be met within the most efficient amount of time.

Typical data sets used in highway and bridge needs models include:

1. Highway Performance Monitoring System (HPMS) pavement data and
2. National Bridge Inventory (NBI) data.

Examples of needs models include the federally supported Highway Economic Requirements System for States (HERS-ST) (FHWA 2009), the National Bridge Investment Analysis System (NBIAS) (FHWA 2010a), as well as the privately syndicated Deighton asset management software. Most of these tools support cost–benefit analysis, comparing the cost of investing in maintaining a given performance standard with the economic cost of failing to make such investments. The greatest strengths of needs models for understanding disinvestment include:

- Consideration of both life-cycle and user costs of not investing in assets in comparison with the costs of investing,
- Rigorous detail regarding how engineering measures of effectiveness and performance are affected by changing asset conditions over time, and
- The ability to assess the sensitivity of user costs and agency costs to different funding levels and different sizes of investment gaps over time.

Key weaknesses of needs models for understanding the economic implications of disinvestment include:

- Reliance on fixed traffic growth rates to assess future demand can result in an artificially high "needs" picture and lead to overinvestment, and fails to account for network effects of bridge closures or deteriorating asset conditions.
- Reliance on large databases and statistical average costs that do not account for risks associated with disinvestment or underinvestment in high-impact "outlier" facilities.
- Failure to account for potential changes in infrastructure costs or user costs over the life of the analysis.
- The publicly available needs models such as HERS-ST and NBIAS represent a generic "baseline" for predicting needs, conditions, and future user costs. More intricate systems, while available to states, can be costly to implement and require significant capacity building at the agency level.

Needs models are a useful tool for understanding disinvestment because they can provide a ready comparison of different futures assuming different funding levels (or no funding). Although needs models are currently not structured to answer questions about disinvestment per se, their basic computational structure lends itself to analyzing disinvestment, at least at the program level. Current needs models simply assess underinvestment (quantifying the economic costs of unmet needs); however, such models may be slightly modified to assess disinvestment (giving the agency savings and user costs of lowered performance targets for programs). However, applying today's needs models to assess the economic costs of disinvestment ultimately will pose challenges beyond simply assessing the economic implications of changing how needs are defined.

Overall, today's needs models rely heavily on a static picture of future socioeconomic conditions and a static understanding of cost and demand patterns. Because the models rely on average annual traffic growth rates applied to a standard demographic or business profile of the user population, such models inherently fail to recognize the shifts in demand and user values that make disinvestment necessary. These static assumptions about future demand and use can result in an inflated understanding of needs (and benefits) for some programs to the detriment of other programs that may be more likely to be beneficial in the long term under actual future conditions. In a similar problem, needs models tend to treat similar facilities identically with regard to the user costs of deficiencies. For example, the bridge needs model (NBIAS) applies an average detour length and user cost to bridges based on the area type (urban vs. rural) and functional classification of the roadway the bridge is supporting. The actual location of the bridge relative to key trade centers and redundant alternative crossings could have significant implications on the "real world" economic cost of a bridge closure (or failure) overlooked by the generalizations of NBIAS.

A key area of future research for understanding the economic implications of disinvestment is in enhancing the value of needs models by integrating them more fully with other types of models used for assessing needs and outcomes, as well as developing new and more rigorous tools for sensitivity testing of future needs assessments.

Demand Models

Transportation demand models are widely used by MPOs, as well as an increasing number of state DOTs. Typical travel demand models arrive at estimates of future traffic flows by deriving future trips from expected socioeconomic conditions, distributing trips based on likely future development patterns, and assigning trips to appropriate modes or routes. Software packages such as CUBE Voyager, EMM-3, and TRANSCAD are often used to develop these types of modeling applications. For freight movements and truck flows, privately syndicated models (e.g., the IHS/Global Insight TRANSEARCH data set) can provide estimates of commodity flows at the region or county level. Freight demand models underlie the U.S.DOT Freight Analysis Framework, which can be used to visualize and query commodity flows to and from different locations (FHWA 2012a).

Demand models are useful for understanding disinvestment scenarios because they can show how traffic patterns would be expected to divert if a given facility or system were unavailable as a result of deteriorating conditions. Unlike the static demand assumptions common in most needs models, network demand models can assess and compare the mileage and hours of additional congested and uncongested travel distance and time imposed by lost use of an asset. When linked to land-use models such as UrbanSim (University of California

Berkeley and University of Washington 2011) or CubeLand (Citilabs 2014), network demand models can also consider changes in spatial patterns of employment and housing when a transportation network changes. The greatest strengths of demand and network models for analyzing disinvestment scenarios include:

- The ability to realistically identify alternate traffic routings and assess changes in travel time and cost when the capacity or connectivity of a facility is lost.
- Consideration of likely future employment and residential location patterns that may drive the future demand for both the disinvested facility and likely alternate facilities.
- The ability to change socioeconomic assumptions about housing and employment locations as part of a disinvestment scenario.

Key weaknesses of demand models for assessing disinvestment scenarios include:

- They can only address mileage and travel time-based economic implications of disinvestment (they do not assess life-cycle, safety, or other types of user costs).
- They do not include any analysis of likely capital costs (or savings) of a disinvestment scenario—they only consider how the scenario will affect network behavior.
- They typically only address high-level, regional, or system outcomes (most travel models do not include intersection of micro-level transportation performance outcomes).
- They do not implicitly convert travel time and operating cost changes into economic costs or benefits, much less economic impacts.

Effectively, demand models are intended as intermediate inputs to economic models. By themselves they are insufficient for any type of economic analysis. However, if they can be used to supplement or complement needs models, they can fill in the gaps that many needs models have for fully assessing disinvestment scenarios.

A key area of future research into the economic analysis of disinvestment scenarios pertains to the integration of demand models with needs models. Such integration may enable needs models to more comprehensively answer questions about how many users, vehicle-miles, and vehicle-hours of travel may be subject to different types of deficiencies as different links or corridors of a network shift to lower performance standards resulting from disinvestment. A key to enabling this progress involves addressing metadata issues such as inconsistencies between the linear referencing systems used in needs model databases (such as HPMS and NBI) and typical geographic information system files used in travel model networks. Current federal initiatives, such as the FHWA's integration of HERE data with HPMS, are promising directions integrating real-time data with more static information.

Another key area for travel demand models is evolving the travel modeling paradigm to regularly consider different possible socioeconomic futures and different associated levels of demand. Although travel demand models can assess the demands associated with different land-use and economic scenarios, in practice most models are validated to a single vision of future land-use and economic growth and only used to test different network assumptions for accommodating such growth. Future research into how to most effectively incorporate different socioeconomic issues into travel model scenarios is an important need for assessing the economic implications of disinvestment planning.

Risk Analysis Methods

As disinvestment becomes more a part of transportation investment management, agencies are likely to employ models for assessing the risks of disinvestment—especially given the uncertainties regarding future demand, potential failure, and costs that may accrue if either a facility continues to be overinvested in and use fails to justify life-cycle costs or, more likely, a facility is disinvested to too far below a performance standard, and the new standard proves insufficient leading to failure.

MAP-21 legislation recognized and called for the application of "risk based" planning, and methodological research has identified and tested methods to assess both the risk associated with a demand forecast and the risk associated with estimating financial highway and bridge investment needs. Mehndiratta et al. (2000) present practical applications and challenges facing planners when addressing investment risk, in terms of "real options." Kruger (2012) offers statistical measures of risk in demand levels associated with different GDP assumptions over different time horizons. Alasad et al. (2014) explored demand risk as it relates to return on investment within the context of public–private partnerships and Maconochie (2010) describes the development and application of highway bridge risk models for use in asset management investment decisions.

A typical risk assessment would assign a risk factor to a project based on past agency experience of project outcomes within certain parameters. If the agency is able to track the actual outcomes (or costs) that have accrued from other similar decisions, either to the agency or to users in actual situations where a facility has performed at the lower performance level envisioned for a disinvested facility, the agency may be able to quantify the likely risk of different types of costs and multiply that likelihood by the magnitude of the cost for use in a traditional cost–benefit analysis. However, agencies often have a lack of suitable case examples, much less databases of disinvestment to realistically base decisions on this type of assessment.

Consequently, statistical methods can also be used for agencies to assess the likely risks of disinvestment. The second moment method (calculating likely risk based on the standard deviation in cost based on the average values of cost determinants) could be applied to user costs in a disinvestment situation to assess risk, as could Monte-Carlo simulations (computerized probabilistic calculations that use random number generators to draw samples from probability distributions). One final risk assessment methodology entails constructing decision trees in which the agency may value all possible outcomes, and then assign probabilities to each possible outcome. Decision trees can be helpful for mapping out the likely economic costs of disinvestment, but are not particularly helpful in determining how the values are to be determined in the first place. Also, decision trees can become very complicated if they are intended to cover all of the possible outcomes for all of the possible determinants of the economic implication of a disinvestment scenario.

All three of these statistical methods are far from precise and are likely to pose challenges to transportation agencies dealing with the open-ended types of variables that come into play when considering transportation disinvestment. For example, it is much easier to simulate the likelihood that right-of-way for a new road will cost $1 million versus $2 million than it is to simulate the likelihood that (1) demand on a disinvested facility will exceed its forecast, (2) such demand will cause performance failures, and then (3) the performance failures will affect the economy.

For this reason it is likely that risk analysis will play an important but limited role in disinvestment economic analysis, applied only at points in the decision process where there is a manageable range of outcomes for a manageable set of economic performance indicators and when the overall structure of the disinvestment scenario is already largely defined by other types of models and tools.

Impact Models

Impact models are widely used to assess the economic impacts of investment or disinvestment scenarios. The scenarios can be at the level of individual projects, bundles of projects, or entire programs. Typically, impact models will be applied when the economic cost of the disinvestment outcome is known and translate the cost into earnings, output, employment, GDP, and other economic outcomes using a standard input–output framework. The REMI TranSight and TREDIS models are examples of widely used economic impact models that might be applied to assess a disinvestment scenario (REMI 2013; TREDIS 2014).

REMI TranSight and TREDIS are both regional economic impact forecasting and simulation models that are specifically tailored for forecasting the impacts of transportation system changes on the economy of surrounding regions—cities, metropolitan areas, states, or broader regions. Their typical inputs fall into six classes:

1. **Traffic Volumes and Vehicle-Miles of Travel Change**—representing effects of route diversion and travel distance changes that may result from facility closures and size and/or weight restrictions.
2. **Vehicle-Hours of Travel Change**—representing effects of speed slowdowns that may result from speed reductions as well as route diversions.
3. **Vehicle Damage Change**—representing effects of decreased road pavement ratings that lead to more vehicle damages associated with potholes.
4. **Travel Time Reliability Change**—representing effects of reduced effective capacity on some facilities, as well as concentration of traffic (demand) on other facilities that are kept to a higher standard.
5. **Market Access Change**—representing effects of shrinking labor markets and/or truck delivery markets owing to reductions in speeds and routing options.
6. **Intermodal Connectivity Change**—representing options for use of intermodal facilities, ground access routes, or connecting services.

The regional economic impact models will translate these six classes of inputs into various measures of change in business operating costs, household operating costs, and productivity resulting from shifts in business operations technology and agglomeration scale benefits.

Although impact models can be helpful for describing the likely economic effects of transportation disinvestment, they can only be used when the disinvestment case has already been largely established through travel demand and needs models. In addition to the private economic impact models, public tools such as those described in NCHRP 2-24 (http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP02-24_Task1LitReview.pdf) assess productivity and other economic outcomes in general terms based on the same types of inputs enumerated earlier. Some of the uses of economic impact models for assessing a disinvestment scenario include:

- Understanding which industries will be most affected by the outcome, and the relative magnitude of how industries will be affected by the lower performance standard or alternative facility or program;
- Consideration of the indirect and induced effects of disinvestment as the costs of the choice are passed through the economy to buyers, suppliers, and households affected by the business outcomes; and
- Consideration of potential feedback loops whereby the costs of disinvestment may cause structural changes in a regional or local economy, further affecting demand patterns. (This would entail using an impact model together with a demand model.)

Some of the limitations of impact models for assessing a disinvestment case include:

- Not showing the initial change in the transportation cost structure, which may be caused directly by the lowered performance standard or switch to an alternative

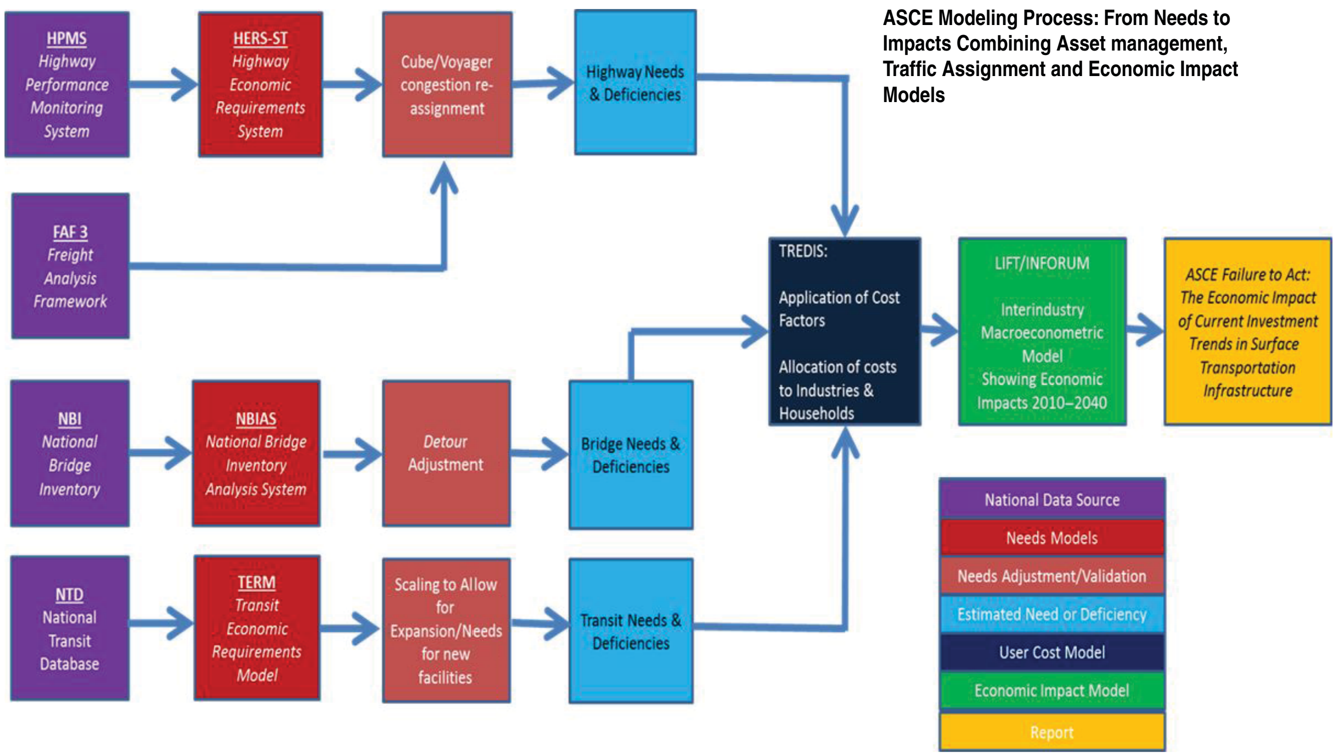


FIGURE 7 ASCE modeling sequence.

facility (they only show how this cost affects the larger economy).

- Can be costly to implement as a regular part of transportation investment decision making and may not be available to all states.
- Can be difficult to explain, as they show "multiplier" effects (indirect and induced effects of transportation costs) that may not be intuitively obvious to decision makers based on an understanding of the nature of the disinvestment scenario.

Overall, impact models have an important role in understanding transportation disinvestment scenarios; however, as with risk models and travel demand models, they cannot help the analyst to formulate the options or directly associate the disinvestment scenario with the initial cost borne in the economy. A key area for impact models in assessing disinvestment scenarios will be in establishing the "base case" and "disinvestment case" transportation user costs such that traditional impact methods can then be applied.

Sequences of Models

It is most likely that disinvestment outcomes will require arranging needs models, demand models, risk models, and economic impact models into comprehensive sequences in which each model provides one key part of the disinvestment picture. For example, demand models can be used to provide more dynamic estimates of future utilization associated with more realistic economic growth and land-use scenarios to inform needs models (possibly informed by risk models to assess the most likely demands). Subsequently, various possible needs assessments for different possible economic futures can be tested on a variety of investment levels representing different likely future economic circumstances, showing diverse investment gaps that then provide the basis for impact analyses of possible needs under different socioeconomic futures.

Although this sounds like a potential "jumble" of models, the flow of information between models can be very intuitive, as demonstrated in Figure 7 from the 2011 ASCE Study (ASCE 2011).

CHAPTER THREE

SUMMARY OF CASE EXAMPLES OF DISINVESTMENT

To provide a high-level, cross-cutting summary of case examples, this chapter presents seven case examples of transportation disinvestment. Although the cases are presented as narratives, the narratives are structured to consistently assess and compare key aspects of economic understanding in each disinvestment situation. The case narratives are presented in a common structure examining the circumstances and context of the disinvestment situation; the interviewees understanding of the decision as an example of disinvestment; the decision-making process, including consideration of economic implications; the types of scrutiny to which the decision was subject; and finally the lessons that can be learned from the experience. The case examples culminate in a synoptic comparison of the cases and what they reveal about the current state of the practice in understanding the economics of transportation system disinvestment.

LONG TIMELINES OF ECONOMIC IMPACTS FROM DISINVESTMENT: MINNESOTA DEPARTMENT OF TRANSPORTATION

For the Minnesota DOT (MnDOT), the disinvestment situation arose as part of its most recent four-year planning process and was triggered by an identified shortfall of revenue. The agency made the decision to partially disinvest in maintenance on non-National Highway System (NHS) assets within the state, as a result of altered investment ratios triggered by the MAP-21 emphasis on the NHS. The disinvestment situation affected an entire class of roads—Non-NHS roads comprise approximately 55% of the state highway system (Minnesota DOT 2013a). MnDOT recognized and understood the disinvestment as it occurred, but nevertheless believed it was constrained in its decision to accept steadily declining conditions on the non-NHS system.

Leading up to the decision, MnDOT conducted a program-level tradeoff analysis between different categories of investment (e.g., pavement, bridge, safety, pedestrians, and bicycles) and decided to "take the hit" in non-NHS pavement. The available alternatives at the state level were constrained by the policy focus of federal legislation on the NHS. Pavement quality targets remained the same following the decision. However, the accepted gap between the target and projected conditions increased the percentage of poor ride quality on the non-NHS system from 7% to 8% in 2013 to 11% to 12% in 2023—well above the current standard of 5% to 9% poor (Puentes and Prince 2003). This instance of disinvestment followed an earlier decision to lower pavement performance targets, also prompted by constrained funding. In 2010, the target for non-principal arterials was less than or equal to 3% poor quality (Minnesota DOT 2010). In 2011, the target was changed to a band of 5% to 9% poor ride quality for the state highway system (Minnesota DOT 2011). In Minnesota, the ability to identify disinvestment is closely tied to the use of performance measures. Economic implications were not explicitly assessed as part of the current disinvestment situation, but were discussed anecdotally as part of the public involvement process (e.g., industry representatives shared stories about how they avoid certain highways to lessen damage to trucks and goods).

Discussing their confidence in economic assessment methods, MnDOT staff pointed out that there is a time dimension that makes it difficult to both assess and communicate the economic implications of deteriorating pavement quality. Projections of poor pavement quality are made 10 to 20 years into the future, and much is likely to change between now and then. On the policy side, the remoteness of the negative impacts prompts a process of rationalization (i.e., people assume that things will change, funding levels may improve, technology available for maintenance may improve, and/or demand profiles will change). On the impacts side, the uncertainty of future economic conditions appears to make economic analysis intractable or at least so uncertain as to not merit the additional effort required. Both industry composition and industry dependence on transportation are likely to change significantly in the next 10 to 20 years. There is a feeling within the agency that because the poor pavement conditions will not appear "tomorrow," expressing impacts in performance rather than economic terms is probably all that is justified in terms of analysis and communication. On the other hand, if the degradation being assessed were immediate, according to MnDOT it would make sense to start asking question such as: Which businesses are affected, and in what ways? Is the primary affected trip-purpose commuting, transport of raw materials, or delivery of goods?

The decision to accept deteriorating pavement conditions was communicated as part of the overall outreach process for the statewide planning process. It was difficult for the public to grasp what pavement would look like 20 years into the future. A picture-based/storytelling method was used to try to overcome this. For example, presentations narrated a fictitious trip from one part of the state to another, with information and images presented about what kind of pavement a user would traverse in the course of that travel. User costs were not explicitly presented; however, some advocacy groups within the state did try to offer this type of analysis.

Overall, MnDOT highlighted the need to communicate all investment and disinvestment situations in terms of the resulting return on investment (ROI). For example, a recent study developed in concert with stakeholder groups from both the public and private sectors estimated an ROI of 3.1 for a 20-year program of maintenance on the state's highway system (Minnesota DOT and Smart Growth America 2013b). The analysis uses a combination of benefit–cost and life-cycle-cost techniques, along with the proprietary PRISM analysis system. Further details of can be found in the study's technical report (Minnesota DOT and Smart Growth America 2013c). Interviewees emphasized the inherent difficulty of communicating and assessing impacts that occur far into the future. It is not clear from the agency's experience whether more data would be helpful in this process; the agency would need to be shown the clear value-added of conducting an economic analysis (as opposed to just communicating effects in performance terms). On the other hand, there is interest, more broadly, in understanding economic implications of the conditions of the transportation system. MnDOT is involved in various case-based research efforts seeking information from industry stakeholders on their transportation needs. Additional work is also underway to extend current ROI methodology to include impacts on economic competitiveness, environmental stewardship, social equity, public health, and livability (C.A. Zelle, MnDOT Commissioner, personal communication, draft invitation to join transportation stakeholder group, July 8, 2014).

The ongoing *Transportation Planning to Support Economic Development in Minnesota* project is being conducted by the Humphrey School of Public Affairs at the University of Minnesota to "identify the relationship between transportation and economic development by investigating how firms use transportation networks and what role they play in the formation and growth of industry clusters" (Minnesota DOT 2014). Previously, a pilot study of manufacturers' perspectives on transportation in southwest Minnesota was completed (October 2013) in a joint effort between the University of Minnesota and MnDOT (University of Minnesota 2013a). The agency believes that these types of efforts can create significant value. However, interviewees expressed reservations as to whether the case example approach is clearly replicable or scalable. The agency staff also believes that case example material from elsewhere would be useful as long as certain common baseline characteristics were shared (e.g., industry composition). Interviewees believed it would also be productive to do a comparative analysis among different areas of the country to identify the significance of particular variables (transportation or otherwise) in supporting industry activity and clustering.

DEFERRED MAINTENANCE, BRIDGE CLOSURES, AND THE MOBILITY–PRESERVATION TRADEOFF: SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

In South Carolina, the decision was made to temporarily suspend state-funded resurfacing, and more broadly to reduce the state's budget for routine maintenance and operations. The disinvestment situation was triggered by funding shortfalls that made it difficult for the state to meet its federal-aid match requirements. To not lose out on federal funds, cuts had to be made elsewhere in the state's budget. The cuts were made for the more than 50% of the state's highway system that is not eligible for federally funded resurfacing.

From the agency's point of view, this was a forced disinvestment (not to do so would mean a much greater loss of funding from the federal program). It was made with a broad understanding of the consequences; however, there was no specific analysis of economic implications. Interviewees discussed the generally understood life-cycle cost of deferred maintenance (i.e., if a section of pavement had been a candidate for a particular treatment but did not receive it owing to funding shortfalls more costly reconstruction is likely to be needed in the future). Another operations-related disinvestment situation that occurred was the decision not to replace equipment and to continue sinking money into an asset that has little salvage value, simply because the capital is not available to purchase new equipment.

The department did not undertake any economic analysis addressing the disinvestment situation. According to interviewees, a more informed decision would not necessarily have changed the resulting disinvestment scenario. More broadly, the agency is working to improve its asset management approaches and hopes that as they improve the agency will be better able to make specific decisions about how to spend the very limited state discretionary operating funds. The state does not currently have specific performance targets for pavement; these will be developed to comply with MAP-21. South Carolina DOT (SCDOT) staff believes that establishing performance targets will aid in communicating the gap in funding and its performance implications. All investment and disinvestment situations within SCDOT receive general scrutiny from both the public and the legislature. According to interviewees, the types of decisions that elicit feedback from the public and elected officials are those with high visual impact (e.g., the decision to cut back on mowing the grass). Pavement deterioration, on the other hand, is a slower process with less immediately visible outcomes.

Interviewees also discussed the issue of posted and closed bridges, noting that they had not necessarily thought of those as instances of disinvestment. There are two general types of bridge closures and restrictions. The first type includes temporary closures of bridges that may already be on a priority list but have not yet progressed through the process of design and implementation. The second type encompasses what this project considers to be a disinvestment situation: the closing of bridges with very low volumes. From a priority perspective, these bridges will never be ranked high enough to receive funding. Prioritization is based primarily on the Pontis system (a software application developed to assist in managing highway bridges and other structures based on expected needs and user costs), with some allowance for engineering judgment based on factors such as the district's ability to maintain or repair a bridge and the location of schools, fire stations, or emergency medical facilities in an area. Economic assessments are not performed. SCDOT believes that in most situations traffic volumes and the length of the necessary detour are good enough proxies for the economic impact of closures. However, there are cases where industry-specific information might be of use—such as where there is a closure or posting of a bridge used by the timber industry. Even though that usage many not amount to high volumes, these connections are important determinants of the "cost to haul" for the industry. SCDOT understands this cost implication and has been alerted to it by stakeholders; however, the cost implication is not explicitly quantified. In considering economic assessments of bridge closures or postings, the agency notes that such analysis is unlikely to "move the needle" much within the current assessment framework. It is, therefore, unclear from the agency's perspective whether the extra effort is worth the resource cost.

Finally, interviewees identified an agency-wide struggle between preservation and mobility. They framed the decision in the following manner: If you decide first and foremost to maintain what you already have, you are making an implicit decision not to invest in mobility. The erosion of mobility then appears in the form of congestion costs. This conflict is compounded by the issue of regional equity. From a mobility perspective, the bulk of investment needs in South Carolina will always be in urban areas. On the other hand, in rural areas the argument is that infrastructure is needed to attract development and jobs. There is an economic tradeoff that the agency struggles to quantify: between the potential for economic development as a function of infrastructure provision in rural areas and the cost of congestion and the eroding mobility to the economic activity within urban areas. Consequently, SCDOT staff indicates a belief that economic implications can be an important determinant of combined investment and disinvestment strategies.

INVEST TO DISINVEST AND UNINTENDED CONSEQUENCES: NATIONAL PARK SERVICE NORTHEAST REGION

Within the National Park Service (NPS) Northeast Region (NER) a series of disinvestment situations have been prompted by implementation of national guidelines on asset management. The nationally defined approach is based on a joint determination of asset priority and condition (for all park assets, including roads and bridges). The resulting score is used to prioritize investment and to identify projects for disposal (disposal meaning removal from the NPS preserved assets).

The asset priority index (API) is used to quantify the relative importance of NPS infrastructure. Calculated out of 100 possible points, the API is a weighted scoring system based on five criteria aimed at linking asset performance to the NPS core mission: (1) natural resource preservation, (2) cultural resource preservation, (3) visitor use, (4) park operations, and (5) asset suitability. The first four criteria capture different facets of the core functionality of the NPS. The fifth criterion, "asset suitability," represents the degree to which a comparable substitute is available for a given asset. Scoring in this category answers the question: "if the asset were lost, what would be the impact?" This question is particularly applicable when considering the network-nature of road systems. The Facility Condition Index (FCI) is the ratio between an asset's projected cost of repairs and its current replacement value. The FCI is used to rate the facilities along a spectrum from good to serious condition. The API and FCI scores are then used to place each asset into one of five "optimizer bands" that define the appropriate level of investment for the existing asset (National Park Service 2014). Funding is (by policy) channeled toward Band 1 and 2, leftover funds are directed to Band 3, and Band 5 is flagged for disposal.

The NPS NER case is an example of a program-wide disinvestment policy, managed internally within each region and subject to scrutiny from the national agency. Despite the intentionality of the prioritization policy, there are ambiguities about what constitutes disposal (e.g., is it simple abandonment of a road, bridge, or parking lot or does disposal require costly full removal of the asset and restoration of natural conditions?). Although the disposal policy was made intentionally, the NPS NER believes that outcomes of these disinvestment situations are not fully anticipated or accounted for—particularly in the category of disposal costs and network effects on other portions of the park system.

According to the NPS NER, the economic consequences of the disinvestment situation are not defined or well-understood. The types of unaccounted for economic implications include: (1) impacts on the ability of a park to attract and handle increased visitor traffic, and (2) changing patterns of visitor spending within adjacent communities as a result of changes in the transportation network. By prioritizing maintenance on the most important transportation network segments (defined in terms of the park assets that those network links serve), traffic will tend to be funneled into a small subset of the parks area, thus creating congested conditions, putting disproportionate pressure on certain parts of the system, and redirecting visitor engagement from one portion of the park system (and adjacent communities) to another. In addition, the NPS NER believes that the path-dependence of disinvestment is not adequately considered. If policy changes and the NPS wants to restore a piece of the transportation network to operable conditions, this will likely require a significant amount of investment.

Overall, the NPS NER experience offers two primary lessons. First, disinvestment is far from zero cost; significant costs are likely to be incurred, ranging from enforcement of closures to the expense of physically removing an asset and restoring the condition of the area afterwards; and these costs need to be weighed against both the savings on maintenance and the performance effects of removing part of the transportation system. Second, a prioritization scheme that focuses on top priority assets can only result in a form of unintended blindness to the role played by lower priority assets. Although prioritization is undoubtedly important for making due within fiscal constraints, it might be accompanied by a strategy for quantifying and monitoring the system-level effects of removing portions of the transportation network.

CHANGING DEMAND, DISINVESTMENT AS A BASE CASE, AND BUSINESS INPUT: SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

Although the focus of the current synthesis is on highway and bridge assets, the rail experience can be instructive for understanding how to approach the economics of transportation disinvestment. The details of this South Dakota rail case example do not fully fit the analytical structure of the other cases; nevertheless, the case is instructive because it highlights links between disinvestment and investment within an overall strategic approach to transportation system performance and need.

In responding to inquiries for cases, South Dakota DOT (SDDOT) reported a case of investment that actually reversed previous private-sector rail abandonment and disinvestment [i.e., a $28.3 million improvement of a state-owned rail line, supported by a federal Transportation Investment Generating Economic Recovery (TIGER) grant (discretionary grants that fund capital investments in surface transportation infrastructure)]. Sixty-one miles of the rail line that parallels Interstate 90 in central South Dakota was rehabilitated between Mitchell and Chamberlain; improving access for the region's agricultural sector. The rehabilitation decision was triggered by the availability of a TIGER grant and changing economic conditions in the area, including increased agricultural production per acre (as a result of improved agricultural practices, plant genetics, and more efficient farm consolidation) and increasing global demand for agricultural products.

The interviewee viewed investment and disinvestment as two sides of the same coin: "the opposite of disinvestment is investment." Analytically, the base case of an investment scenario is the build case of a disinvestment scenario. Economic impacts were a large part of the story that supported both the TIGER grant application and the overall project. The DOT considered the costs and benefits associated with the diversion of goods and mode switching between truck and rail. According to their analysis, the rehabilitation project enables greater profits per bushel reflected in the lower costs to transport grain—a function of shortened trucking distances and reduced wait times for unloading. The project also reduces the impact of trucks on highways.

What makes this investment case example unique is that the rehabilitation project actually reversed a pattern of private-sector rail abandonment and disinvestment over many years. Moreover, the decision to improve the line is an example of an agency exercising a "real option" (as described in chapter two). The option was purchased much earlier when the rail line was first acquired by the state from private-sector owners who no longer found it profitable to continue operations. By acquiring the line, SDDOT created the option to restore higher levels of service in the future if demand improved. In the interim, disinvestment occurred because of resource constraints and insufficient users and demand to warrant project investment. Eventually, SDDOT determined that the economic conditions and the expected demand had improved adequately to justify investment. Because the line was in state ownership, the cost to upgrade was less than it would have been to acquire land and build an entirely new line. In this example, SDDOT made an initial investment to acquire the option to later upgrade service without starting over (and thus incurring the greater costs required to start from nothing). Ownership of the rail line gave the agency the flexibility to wait until line rehabilitation became a prudent choice, because of changes in demand and funding. The agency then exercised its previously purchased real option.

SDDOT was also asked if transportation disinvestment was studied outside the context of defining the need for a transportation project or service. In response, the interviewee noted that there are resource barriers to doing so and that all analytical efforts go into trying to study and support "investments that appear to offer the greatest return." Nevertheless, the agency does believe that it can identify instances where resource constraints have led to unintentional disinvestment or insufficient investment by users and the public. Key industry stakeholders often provide input when they believe additional investment is needed. This highlights that defining transportation system performance can be difficult depending on the level of complexity of the regional transportation and economic system. A state with a large export-based economy such as South Dakota may be able to define tradeoffs and economic needs vis-à-vis transportation more clearly than a state with many sectors and conflicting demands. As stated by the interviewee: "We listen to stakeholders." In general, SDDOT believes that before-and-after studies of economic impacts from previous projects can also be useful when faced with a disinvestment situation, as they seek to identify the forgone benefits associated with limited revenues and resource constraints.

EVOLVING PERFORMANCE NEEDS, ECONOMIC OBJECTIVES, AND THE URBAN INTERSTATE: CONNECTICUT DEPARTMENT OF TRANSPORTATION

This Connecticut case example describes an instance where varying degrees of disinvestment are under consideration by the DOT for replacement of an urban interstate. The section of I-84 that runs through downtown Hartford is nearing the end of its useful life, requiring more intense and more frequent maintenance and rehabilitation work. In addition, the viaduct is characterized by transportation performance deficiencies, including operational problems at interchanges that handle volumes as much as three times their original design capacity. The deficiencies result in what the agency views as unacceptable levels of congestion and an unacceptably high accident rate for the corridor. Connecticut DOT is now in the early stages of The I-84 Hartford Project, which will define needs and deficiencies, develop alternatives, move through the NEPA process, and ultimately adopt and implement a preferred alternative (Connecticut DOT 2014c).

A 2010 joint study by the city of Hartford, Connecticut DOT, and the Capital Region Council of Governments (CRCOG) compared different replacement strategies (including tunnels, at-grade replacement, and viaduct modernization) with goals related to transportation performance, urban design, and economic development (CRCOG 2010). The I-84 viaduct is just one example of an urban interstate that is currently being assessed to see if its current form still meets community needs and a current understanding of performance. The Congress for the New Urbanism, an advocacy group focused on "walkable, mixed used development, sustainable communities, and healthier living conditions" (Congress for the New Urbanism 2011) publishes an annual list of "Freeways Without Futures," which has argued that there may be locations in North America where greater economic growth could be stimulated by replacing urban highways with other lower-impact forms, such as urban boulevards (Congress for the New Urbanism 2014). The conversation around "highway removal" is indicative of a planning paradigm for urban interstates that has changed over the last 50 years. Many urban communities are moving toward an increased focus on ground-level connectivity and economic development and questioning whether the large footprint of urban interstates and access ramps should be re-designed to meet broader development goals. At the same time, the role played by interstates in regional access and freight movement remains important.

Alternatives for the I-84 project are currently under development. There are three general replacement options available, which could be combined in a number of ways: replacement with modern bridges, at-grade replacement with rail relocation, and a below grade tunnel. These options could be combined with other strategies including potential realignment of the rail line and viaducts that are located in the same corridor. One of the primary reasons that I-84 was initially built as a viaduct was to cross over the railroad (twice) (Connecticut DOT 2014d). A likely scenario that would maintain interstate functionality while also meeting local economic development objectives would be to modernize the design to have a smaller footprint, with consolidated and/or rebuilt access ramps. This project is included as a disinvestment case example because some of the reconstruction options would lower performance in certain categories or remove parts of the structure to increase performance in other areas. The case highlights the types of choices faced by managers of aging infrastructure when both demand profiles and a community's understanding of needs may have shifted since the original construction.

The evaluation process for the I-84 project has yet to begin. According to Connecticut DOT, socioeconomic impacts will be reviewed and considered as required by the NEPA process. In terms of specific analyses, a likely assessment method for economic impacts will be to look at market conditions for residential or commercial uses on the land that would be freed up by each of the design alternatives. Life-cycle costs are likely to be a key driver of the final decision.

Connecticut DOT expressed general confidence in the NEPA process to adequately capture economic implications of the different alternatives. The interviewee did, however, point out the funding risk for a large project such as this. That is, even if an alternative is determined to be the most desirable, there is the very real possibility that funding will not materialize and the base case will become a de-facto build case. The base case carries with it significant operational costs that would be borne disproportionally by the state (as compared with the project case that would presumably receive a high percentage of federal funds).

A public Advisory Committee has been convened to provide input to the process. In that setting, Connecticut DOT is navigating some degree of conflict between stakeholders interested in different dimensions of economic development. There is tension between objectives related to market and freight access that depend on longer-distance, high-speed travel along the interstate and local development that could be supported by better connectivity at ground level and more developable land.

In terms of lessons learned, this case demonstrates how consideration of disinvestment can be triggered by increasing maintenance costs, changing demand, and by a changing understanding of the performance goals for a particular piece of infrastructure. This is particularly true in the case of urban interstates, but applies to other types of transportation assets as well. The case also highlights the close link between disinvestment and investment. Even at the corridor or single-asset level investment and design strategies may be updated to strategically shift emphasis toward one set of objectives (e.g., improving local connectivity and land development potential) and away from another set of objectives that had previously received more emphasis (e.g., providing easy access and unrestricted mobility to vehicles within the downtown area). Finally, I-84 demonstrates the influence of policy dictates on available investment strategies. The interstate system has certain mandated performance requirements that prevent some alternatives (such as conversion to a boulevard) from being implemented, unless the status of the roadway is changed.

SIMULTANEOUS INVESTMENT AND DISINVESTMENT: MISSISSIPPI DEPARTMENT OF TRANSPORTATION

Mississippi DOT defines its case of disinvestment as three rounds of funding cuts that were made in the last three years, affecting the entire system and all programs. This phased disinvestment was triggered by a funding shortfall; the agency had been projecting revenue growth of a few percent per year; however, current estimates are now adjusted downward to project flat funding, at best, because of reductions in VMT and revenue from the fuel tax. Cuts were made at the program level and have prompted a closer look at the prioritization process within each area. Mississippi DOT reports a slight shift toward maintenance and away from new investments.

For Mississippi DOT, as with many of the other cases, addressing the disinvestment situation is closely related to investment decisions. In 2002, the state legislature passed Vision 21, which includes requirements to create four-lane highways across the state. The legislatively required investments influence the overall investment and disinvestment strategy of Mississippi DOT both because of the earmarking of certain funds and because maintenance costs were not built into the funding package for Vision 21.

In analyzing the effect of overall program cuts, Mississippi DOT reports not looking closely at economic impacts. From Mississippi DOT's perspective, it appears that calculating economic implications of program cuts would be a useful communication's tool. However, the interviewee was not clear on how such an analysis would change the actual content of disinvestment situations being addressed and therefore believes that the value-added for the extra effort is not obvious. Within the long-range planning process, an economic model is used in conjunction with a travel demand model to examine the economic impacts of investment and disinvestment scenarios for key corridors. The analysis is broad and does not look at project-specific details. Mississippi DOT was also asked about the economic impacts of new four-lane highways planned within the Vision 21 program. It believes that it does not have adequate tools to quantify the economic development that would be forgone if new four-lane highways are not constructed. Thus, the tools are not sufficient to assess economic tradeoffs between budget cuts to transportation programs and investment in greater capacity. Mississippi DOT hopes in the future to more closely work with the Mississippi Development Authority to improve its understanding of the economic implications of different transportation investment strategies.

Responding to questions about scrutiny for disinvestment situations, the interviewee described a parallel but unrelated task force set up by the state senate to review the transparency of decision making within the agency. Industry leaders were involved and raised questions about how Mississippi DOT prioritizes projects. The agency does not believe that that interaction offered any new understanding of the economic impacts of different investment strategies. It did, however, improve communication between economic stakeholders and agency decision makers. In addition, the process increased the visibility of the economic consequences of disinvestment to the state legislature through the involvement of industry leaders (e.g., the Mississippi Manufacturers Association, Poultry Association, and Road Builders Association).

This case example highlights a couple of main points. First, it shows that while economic assessment can in principle be used for both communication of needs and for decision support, it is not always clear to state DOTs how decisions prompted by budgetary shortfalls would be altered by improved economic assessment. There is a certain level of "proving" that has to happen before widespread adoption can occur. Second, the effect of Vision 21 on Mississippi DOT's investment strategies is indicative of a general phenomenon: given a limited budget, policy mandates for a given investment strategy will tend to have ripple effects in terms of the ability of an agency to maintain its assets elsewhere in the system. Although there is a general understanding of this effect, the tradeoff is most often not explicitly quantified.

INTENTIONAL ADJUSTMENT OF PAVEMENT AND SAFETY APPROACHES TO LOWER COST AND MEET NEEDS: WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

The following case example reviews two specific disinvestment situations addressed by Washington State DOT (WSDOT), within a broader context of making proactive choices to change where revenues are invested in order to achieve realistic performance outcomes. As in many of the other cases these decisions were triggered by fiscal constraints. Financing assumptions and bond sales for WSDOT had previously been based on a 4% construction cost index and 3% annual growth in VMT (which determines fuel tax revenue). Leading up to 2007, VMT growth flattened out, while at the same time the state experienced double-digit cost inflation in 2006 and 2007, resulting in a $1.5 billion deficit relative to previous project funding levels. Two very large federal bonds (GARVEE and TIFIA) had also been floated based on the backing from future revenues. This put the agency in a situation in 2007 where it was looking very closely at how to use its *uncommitted* federal and state revenues to preserve existing assets and maintain its programs. Every past practice was "put on the table" for scrutiny.

The interviewees presented details of two specific cases, but were careful to note that the general approach was similar across the board with the agency. One case relates to pavement and the other case is from WSDOT's safety program.

Scrutiny of the pavement program revealed high costs for asphalt paving (hot mix asphalt) relative to chip seal (bituminous surface treatment) treatments. This led to a consideration of roads with higher volumes than the previously established

2,000 average annual daily traffic (AADT) limit for the chip seal treatment. The agency analyzed roads in the 2,000–10,000 AADT range and found that 5,000 miles in the system had a truck load profile (measured in ESALs—equivalent single axle loads) similar to that of the under 2,000 AADT roads. Based on the assumption that truck loading is the primary driver of wear and tear, the agency modified its investment rules to apply the chip seal treatment to the mileage in the 2,000–10,000 AADT range. Given that the pavement depth on the 2,000–10,000 AADT roads was significantly greater than that in the 0–2,000 AADT range, WSDOT considered the decision to be fairly low risk. The DOT believes that while this can be viewed as disinvestment in the strictest sense, it is really an example of using a life-cycle cost-based analysis to support better decision making. Moreover, the agency recognizes that there are opportunity costs associated with continuing the higher-cost investment rule. Continuing to pay for higher-cost treatments where they were not needed would mean encountering a funding shortfall elsewhere in the system. Such a decision would risk cases where deferred maintenance caused other roads to lose their structural integrity and require more expensive reconstruction in the future. Those consequences would in turn amount to passive disinvestment in other parts of the network. As WSDOT views it, the agency opted for a more intentional "disinvestment" strategy to achieve and sustain the required performance characteristics across their system.

In the safety program, scrutiny of investment strategies resulted in the adoption of a more "flexible" approach: WSDOT began to analyze data on the top three types of accidents that caused approximately 70% of fatal and serious injury accidents in the state. The analysis looked for specific contributing factors. The agency then altered its approach to target those specific factors. In their words, this meant a shift from re-designing to "address all things possible" to addressing "all things *probable.*"

In general, the DOT's strategy has been to broaden its horizon for available solutions and to recognize that there are multiple ways to achieve performance. WSDOT works to ensure that communication occurs across programs within the agency to understand tradeoffs between performance in different categories or at various locations within the network. When a particular treatment or program is no longer achieving a high enough return on investment the agency retires the strategy; that is, it keeps track of and identifies cases of diminishing returns. Overall, the agency's approach to updating investment strategies is based on transportation performance rather than economic analysis.

The *Gray Notebook* is used to communicate with the public about performance, conditions, investment decisions, and funding. WSDOT staff refers to this as "performance journalism." The entire program of investment in Washington State is built around legislatively defined performance areas and goals. Going forward, the agency hopes to more closely tie decisions at the planning level down to the specific level where performance is measured.

The interviewees reported that they are, as an agency, currently grappling with understanding the economic implications of different investment and disinvestment strategies. The interest level in new methods is quite high. For example, the agency would benefit from an improved understanding of the land-use implications of transportation investment. They would like to be able to understand how an intersection re-design might trigger new development, which in turn creates the need for further investment in the local road network. Land-use outcomes are viewed as important because they affect not only the economics of the region but also the funding needs of the DOT. In general, WSDOT staff view performance-based planning as a key prerequisite to economic analysis. The agency is also working to incorporate a broad understanding of risk (beyond cost-related risk) into their management; for example, political risk is considered when dealing with safety. If the agency works with a community early on, before performance degrades too far, it can implement lower cost solutions and avoid "mega-fixes" that might be forced from the political arena.

As with some of the other agencies interviewed, WSDOT staff indicated that tradeoff analyses are often missing from higher-level policy discussions, particularly at the national level: Any modification to policy or design standards has both financial and performance implications for state DOTs. WSDOT would like to develop a process that recognizes those implications and then asks if resulting changes are acceptable, given the objective of the proposed policy modification. In their own words, "they're all great decisions; it's just those great decisions have great counterparts."

SUMMARY AND LESSONS LEARNED

Tables 1 and 2 summarize the key dimensions of the seven case examples detailed in this chapter. As can be seen from the tables, there are certain commonalities among the cases. Many of the disinvestment situations are triggered by budgetary constraints (Minnesota, South Carolina, National Park System, Mississippi, and Washington State). A few are associated with changing demand profiles and performance requirements (South Dakota and Connecticut). In many of the cases, agency staff indicated that their investment and disinvestment strategies were partially or fully dictated by higher-level policy decisions, either at the state or federal level. Multiple agencies expressed reservations about conducting economic analysis given the level of effort, because they were unsure whether the added information would actually change the selected disinvestment strategies. They nevertheless viewed economic analysis as important to their ability to communicate the implications of disinvestment, particularly to the public, legislators, and policymakers. Across the case examples, understanding system-level performance was viewed as an

TABLE 1
SUMMARY OF CASE EXAMPLES—PART I

	Minnesota DOT	South Carolina DOT	NPS Northeast Region	South Dakota DOT
1. **Circumstances of the Decision**	Triggered by **funding shortfall**; within the long-range planning process.	Triggered by **funding shortfall**; difficulty in meeting federal-aid match requirement.	Prompted by **national policy** to implement asset management and identify non-critical/poor condition assets for disposal (a cost savings initiative).	**Changing economic conditions** (increased agricultural productivity) **increasing demand** for rail service.
2. **Defining Disinvestment**	**Intentional but constrained decision** to accept declining pavement conditions on the non-NHS system; prior decision to **change performance targets**.	**Intentional but constrained decision** to suspend state-funded resurfacing and reduce the state's budget for routine maintenance and operations; also discussed bridge closures.	Funding channeled by policy to *Band 1, 2, and 3* assets; *Band 5* flagged for disposal; **ambiguity about the definition of disposal (closure versus full removal)**	Rail rehabilitation based on improved demand that **reversed a previous process of gradual disinvestment**; **exercising a real-option** that was purchased when the agency acquired the abandoned line.
3. **Decision Process**	Program-level tradeoff analysis; **no economic analysis** (discussed anecdotally).	Broad understanding of consequences—**life-cycles costs of deferred maintenance and equipment replacement**—but no specific analysis. Bridge closures based on asset conditions and traffic volumes.	Based on a joint scoring with the Asset Priority Index (API) and the Facility Condition Index (FCI); **no economic analysis or consideration of the up-front cost of disinvestment**.	The **base case of an investment scenario is the build case of a disinvestment scenario**; analysis projected greater profits per bushel due to **lower costs to transport grain**.
4. **Confidence in Assessment Methods**	**Long timeline of performance changes** makes it difficult to project future economic impacts (given that much will change in the future).	No economic analysis, but agency is **unsure if a more informed decision would have changed the decision.** For bridge closures, transportation performance viewed as an adequate proxy for economic impacts.	Prioritization scheme neglects the consequences of disinvestment; **unaccounted for effects on visitor usage patterns** within the parks due to disinvestment in part of the transportation system (which has **implications for visitor spending patterns**).	**Resource constraints** tend to focus assessment efforts on investment rather than disinvestment; **input from stakeholders** can be helpful in identifying likely outcomes and cases of passive disinvestment.
5. **Scrutiny of the Decision**	Part of outreach for statewide planning; picture-based storytelling method used to communicate pavement conditions 20 years in the future.	**Highly visual disinvestment receives feedback from the public** (e.g., reduce grass mowing); pavement deterioration is slower and less visible.	Internal process within the Northeast Region, for compliance with national policy.	The more complex the system is, the harder it is to anticipate the effects of disinvestment. South Dakota provides an opportunity to consider a reasonably straightforward example.
6. **Lessons Learned**	• **Long timelines** of performance impacts make predicting economic outcomes more difficult; • **Case example material and outreach to industry** would be valuable; and • Investment and disinvestment strategies are **influenced by national policy.**	• The **value added from additional economic analyses is not always clear** to an agency faced with disinvestment; • Agencies are grappling with the economic **tradeoff between investing in mobility and investing in preservation; and** • Investment and disinvestment strategies are **influenced by national policy.**	• Disinvestment is **far from zero cost;** • The cost to dispose (enforcement, physical removal) and the **performance effects of removing part of the transportation system** should be weighed against savings on maintenance; and • Focusing on top priority assets should not mean forgetting about the **role played by lower priority assets**.	• Investment and disinvestment **may occur cyclically over time to respond to demand shifts;** • **Defining performance** is more straightforward in an example like the South Dakota railroad situation than it might be in more complex or urban systems; and • **Case example material** of project-level economic impacts can help define the **forgone benefits from not investing**.

TABLE 2
SUMMARY OF CASE EXAMPLES—PART II

	Connecticut DOT	Mississippi DOT	Washington State DOT
1. **Circumstances of the Decision**	Elevated urban interstate **nearing the end of its useful life**, requiring more frequent maintenance and rehabilitation; broader context of **changing emphasis on local development and connectivity objectives.**	Triggered by **funding shortfall**; previously expected revenues adjusted downward because of slowing VMT growth and decreased revenue from the fuel tax.	Triggered by **funding shortfalls;** slowing VMT growth and cost inflation eroded agency revenue; bonds backed by future revenues constrain the availability of ***uncommitted* funds.**
2. **Defining Disinvestment**	Reconstruction options (e.g., consolidating access ramps) can be described as disinvestment as they would **lower certain performance standards or remove parts of the viaduct structure in order to increase performance in other areas.**	**Three rounds of funding cuts** at the program level that prompted a closer look at prioritization within each program area; **disinvestment occurred alongside a legislatively mandated 4-lane highway investment program.**	**Changing standard for application of a lower-cost pavement treatment** based on usage patterns; transition to **more targeted safety solutions** based on analysis of accident contributing factors.
3. **Decision Process**	Socioeconomic impacts to be assessed within NEPA; likely to conduct specific analysis of real estate **development potential on land freed up by lower-footprint replacement** designs.	Did not look closely at economic impacts of disinvestment; **economic impact model used to assess broad investment scenarios** for corridors; no project-specific analysis.	Decisions based on **transportation performance tradeoffs** rather than economic analysis.
4. **Confidence in Assessment Methods**	Confident in assessment methods but wary of funding risk: even if alternative is selected, **funding constraints could cause the high-cost base case to become the de facto build case.**	Understanding economic implications appreciated as a communication tool but agency is **unsure if improved analysis would alter the actual** disinvestment situation addressed; tools are insufficient to assess **economic tradeoffs between maintenance and capacity investment.**	Currently **grappling with the need for economic assessment methods**; interested in understanding the **feedback loop between transportation investments, land-use changes, and changing travel demand**; views performance-based planning as a key prerequisite to economic analysis.
5. **Scrutiny of the Decision**	Public Advisory Committee; navigating conflict between **stakeholders interested in economic impacts at different geographic scales** (local vs. regional).	Outreach to industry community as a part of a broad task force on agency transparency; **industry involvement improved visibility of economic implications of disinvestment.**	The ***Gray Notebook* is used to communicate** with the public about performance, conditions, investment decisions, and funding; referred to as **"performance journalism."**
6. **Lessons Learned**	• Disinvestment can be triggered by increasing maintenance costs, changing demand, **and by a changing understanding of performance; and** • Even at the corridor or single-asset level, **designs can be changed to shift emphasis between different categories of performance.**	• The **value added from additional economic analyses is not always clear** to an agency faced with disinvestment; • Policy mandates for a given investment strategy will have **ripple effects** within an agency; and • Agencies want to quantify the economic **tradeoff between investing in mobility and investing in preservation.**	• Some disinvestment situations are really examples of **using a life-cycle cost-based analysis to support better decision making**; • Continuing a **non-optimal investment strategy can result in passive disinvestment** elsewhere within a system; and • A **risk-based approach** can aid in decision making.

important precondition to making strategic disinvestment and investment decisions. Case examples of previous projects and input from industry stakeholders were generally viewed as a useful approach to understanding the economic implications of disinvestment.

The MnDOT case highlights how the long timelines of negative performance impacts from disinvestment can make it challenging to predict economic impacts with a reasonable amount of certainty. South Carolina and Mississippi both pointed to the challenges faced by agencies seeking to understand the economic tradeoffs between investments in system preservation and investments in system capacity. The case example from the National Park Service Northeast Region emphasized that disinvestment can be a costly process, even if it achieves savings in operations and maintenance in the long run. South Dakota's rail rehabilitation case demonstrates how investment and disinvestment may occur cyclically over time to respond to demand shifts. The I-84 project in Connecticut shows how, even at the corridor or single-asset level, designs can be changed to shift emphasis between different categories of performance. Washington State clearly paints a picture of how decisions to overinvest in one part of a system (even passive or unintentional decisions) can result in passive disinvestment elsewhere, because of limited funding.

Overall, the interconnectivity of system performance and the relationship between investment and disinvestment is a key recurring theme. Additionally, many of the cases address risk related to uncertainties of one form or another, including uncertainties of demand; asset conditions over time; financial, policy, and political realities; and future economic conditions.

CHAPTER FOUR

STATE OF THE PRACTICE REVIEW

A survey of state agencies was conducted in March and April 2014. Surveys were completed online and participants also received follow-up phone calls and an opportunity to complete the survey by phone. Forty-one of the 50 state DOTs replied to the survey, including 38 states that completed the survey online, two partial responses (by e-mail and telephone) from states indicating some experience with disinvestment but lacking sufficient available information to answer the 20 questions, and one state responding that they lacked the information needed to complete the survey.

WHO MAKES DECISIONS IN DISINVESTMENT SITUATIONS?

Based on survey data received, states were split evenly in terms of those that had made an intentional disinvestment choice in the last five years: 43% had faced a disinvestment situation, 43% had not, and the other 16% were unsure or experienced only passive disinvestment. This finding suggests that while all states struggle with investment shortfalls and difficult choices, many do not explicitly structure these decisions as disinvestment scenarios or consider their implications as such.

CONTEXT SURROUNDING AGENCY DISINVESTMENT SITUATIONS

Those agencies that did face disinvestment scenarios tended to face choices regarding disinvestment in entire programs or classes of roads (70% of respondents), or for a specific facility (50%). Agencies did not appear to apply disinvestment strongly at the corridor or sub-area level (15%), suggesting decisions are often made at the statewide or district level. This is not surprising given the potential political sensitivities that may surround disinvesting in a very specific location or geographic area.

Consistent with the finding that agencies are inclined to take a high-level approach to disinvestment, the majority of staff indicating experience with disinvestment characterized their disinvestment situation as a "wholesale or incremental disinvestment policy" (63% of respondents), as opposed to looking at a single disinvestment scenario (16%) or a periodic disinvestment scenario (21%).

The State Transportation Improvement Program (STIP)/Transportation Improvement Program (TIP) process was by far the most likely circumstance for disinvestment situations, with 55% of respondents indicating these processes as the context of a disinvestment situation. Other disinvestment contexts included the long-range planning process (30%) or in response to budget cuts (20%). This finding is significant, as it emphasizes the role of disinvestment when agencies are facing tradeoffs in programming (e.g., in the relatively short-term TIP and STIP processes) as opposed to looking at long-range implications (as might occur in the long-range planning process). It is also pertinent that in many cases (20% of disinvestment situations) the disinvestment involved some sort of jurisdictional turnback or agreement among agencies as to an alternative future for the disinvested asset.

Although most disinvestment scenarios were not precipitated by budget cuts per se, the majority of disinvestment scenarios (80% of disinvestment cases surveyed) were ultimately in response to a choice to favor other needs over the disinvested facility in the face of limited funds. Hence, in 80% of cases, the absence of funds to support the disinvested asset at its current level of performance was a consideration in the choice.

DISINVESTMENT TRANSPARENCY AND PROCESS

Practitioners have indicated that unlike new construction or other types of alternatives analysis disinvestment is often more of an internal than a public process. The most common responses indicated that most of the scrutiny on the disinvestment process was internal to the agency, with only some degree of external scrutiny. However, most agencies also indicated that when disinvestment scenarios are subject to public scrutiny and debate they receive comparable levels of scrutiny to other planning decisions.

In most cases, agencies, at the very least, inform the public of a disinvestment situation, with approximately 35% of the agencies involved in such situations actively engaging in structured public outreach to obtain input, and another 35% engaging in structured outreach to explain the decision, even if public input was not part of the decision-making process. Only 15% of agencies indicated that the decision was completely internal to the agency without any information or involvement of outside stakeholders. It is also notable that the majority of respondents (63% of those that engaged in disinvestment situations) engaged in some type of outreach to the business community either as part of the decision-making process or in implementing the decision.

DISINVESTMENT ANALYSIS METHODS

Most (75%) of the respondents who had faced disinvestment situations had engaged in some type of process to ascertain likely economic outcomes; however, the type of analysis varied from simply talking to businesses to engaging in formal impact modeling. The most common assessment (employed by 65% of respondents involved in developing disinvestment scenarios) entailed simply considering the historic performance of the asset (such as traffic count, safety performance, or pavement condition) or reviewing the operation and maintenance requirements of the disinvested assets.

Only 15% of respondents had conducted a formal cost–benefit analysis of disinvestment options and only 10% had conducted an economic impact analysis on a disinvestment scenario. Despite not having widely utilized cost–benefit tools embedded in asset management systems, the majority of respondents indicated fair to high levels of confidence in these methods (average confidence of 2.7 on a scale of one to three). Most also indicated high levels of confidence in spatial and statistical data (average confidence of 2.4) and cost–benefit spreadsheets (average confidence of 2.3).

When asked to assess the desirability of the analysis methods, respondents again expressed a desire for more rigorous analytical approaches. On a scale of from "highly desirable" (3), "somewhat desirable" (2), and "not desirable" (1), respondents indicated the strongest desire for "cost–benefit analysis using an asset management tool that predicts asset conditions," methods based on historical data about asset utilization, or methods based on historical data about asset condition, each with an average score of 2.6. The pattern was similar, with the next most desirable approach being "data about the improvement history of an asset" or "economic impact analysis" (each averaging 2.4). Lowest ratings went to more qualitative methods, such as "identifying analogous disinvestments in other areas" (average 2.0) or "interviewing or surveying businesses and economic development entities" (average 2.1). The interest for better analytical techniques relating to disinvestment scenarios is further substantiated by input respondents provided regarding things that would most help them articulate disinvestment implications to stakeholders. The most common response was for "better models to predict the economic outcomes of disinvestment" (73% or respondents), followed by "better models to predict the implications of disinvestment on transportation performance measures" (65%).

Survey responses pertaining to analytical methods lead to three findings gathered from prior responses: (1) agencies are not broadly using analytical methods to assess the economic implications resulting from disinvestment situations; (2) they are aware of it; and (3) they have a desire for, and greater confidence in, those methods.

REASONS FOR NOT CONDUCTING ECONOMIC ANALYSIS

Given the earlier findings regarding the desire for better analytical methods, it is not surprising that most respondents had low levels of confidence in their ability to anticipate the economic implications of disinvestment. On a scale of one to three (with three as very confident and one as not at all confident), the average respondent rated their confidence in their understanding of economic outcomes of disinvestment as 1.8. The most common response to this question was "not at all confident" (40% of respondents).

Fifty-eight percent of respondents cited limited time, budget, and staff availability as reasons for not undertaking more rigorous economic analysis of disinvestment scenarios. However, another common reason (cited by 50% of respondents) was a belief that either the agency or political leadership was not scrutinizing the decision to a level warranting such analysis, or such analysis would not be likely to have changed the decision made. Not surprisingly, respondents indicated that their agency was more likely to assess the benefits of investment than to assess the dis-benefits of disinvestment.

In summary, the reasons agencies do not conduct economic analysis (for those that did not) reflect pragmatic considerations (limited budget to conduct analysis) combined with some skepticism that the analysis would not have affected decisions.

PASSIVE DISINVESTMENT

Some agencies had not faced intentional disinvestment scenarios, but gave responses regarding passive disinvestment situations they had experienced. The most common way that agencies would know a passive disinvestment situation was occurring was "benchmarking condition and performance, and consistently performing below target performance levels" (84% of respondents). However, responses were common in other areas as well, including "consistent funding levels below assessed investment needs" (77%) and "publicly visible performance failure" (65%).

Overwhelmingly, the reason passive disinvestment had occurred was the result of "recurring funding shortfalls and deferred investment that led to conditions where the costs of 'catching up' seemed insurmountable" (71% of respondents). The second most common reason was "demand for asset increased at a rate faster than anticipated by budgeting, planning, and programming models" (39%), meaning the funding shortfalls were the most compelling reason this had occurred. Most transportation agencies do not have the authority to increase revenues for transportation. If automatic increases do not occur from indexing taxes to fuel prices, increasing VMT, increasing vehicle value from excise taxes, or some other method then the transportation agencies must adjust to flat revenues and inflated costs.

CHAPTER FIVE

CONCLUSIONS

OVERALL FINDINGS

This synthesis found that states are only beginning to proactively consider disinvestment as a meaningful choice in their planning, programming, and systems evaluation, and that economic analysis of such scenario consideration is in its infancy. Although economic methods and tools can lend themselves to a defensible and robust understanding of disinvestment outcomes, practitioners lack the time, resources, or know-how to configure and apply such tools. There is also some question among practitioners as to how reliable such analysis can be given the complexity of factors associated with disinvestment outcomes, as well as whether or not economic analysis could, or would, alter disinvestment outcomes.

To some degree, disinvestment analysis requires adding layers of complexity to familiar planning concepts such as minimum tolerable conditions, investment needs, and travel demand forecasting. However, new concepts such as considering risk and likelihood of future demands, defining "real options" for alternative possible uses of existing assets, and re-thinking the true base case in any economic analysis, must be integrated as well.

The case examples show the current state of the practice, but fall considerably short of illustrating the state of the art in terms of how existing methods and tools can be applied to disinvestment scenarios. The current synthesis suggests a need for case examples to illustrate and demonstrate how existing models, methods, and data can be assembled for different types of disinvestment scenarios. Furthermore, while the survey and case examples primarily address state transportation agencies, it is important to note that the models and data needed for disinvestment analysis, as well as many aspects of disinvestment decision making, are also relevant at the metropolitan planning organization and regional planning organization level.

STATE OF THE PRACTICE

Overall, the findings offered in this synthesis address the current state of the practice; suggest a way forward to a "most effective practice" in disinvestment planning; identify clear gaps in methods, data, and tools; and point to some new approaches and methods appropriate for disinvestment scenarios.

Adequacy, Applicability, and Understanding of Tools

Although a review of available methods, data, and tools finds that economic methods and tools are adequate for understanding the specific types of implications needed to understand disinvestment scenarios, most practitioners cite a practical need for more data and better models and information when facing a decision. For example, of the agencies surveyed for this synthesis, 36% find themselves disinvesting because assets deteriorate faster than originally expected and 39% find themselves disinvesting because demand grew faster than expected. Furthermore, more than 54% cited a need for better data and 73% a need for better models to understand the implications for disinvestment.

This suggests that while intricate models of asset condition, travel demand, economic impact, and societal cost exist, the tools are not currently configured in ways that make it practical to analyze a disinvestment scenario, and agencies have often not found ways to readily apply them. The linkages between needs models, demand models, cost models, risk models, and economic impact models require a level of technical investment and knowledge of infrastructure that is only present in a limited number of transportation agencies. As a consequence, traditional techniques such as cost–benefit analysis, economic impact analysis, risk-based asset management, and travel demand modeling are underutilized when agencies confront a need for developing disinvestment scenarios (as shown by the case examples, literature review, and survey).

Applying the available methods and tools for disinvestment scenarios requires changing the agency business process (and the understanding of planning) such that at least as much attention is given to a disinvestment scenario as an investment scenario. This raises a paradox for agencies—in that to responsibly develop a disinvestment scenario in and of itself requires an investment in the decision itself. It is difficult to raise support (and justify agency resources) for a corridor study, long-range plan, or modeling study with an explicit goal of disinvestment. Such a goal may provide stakeholders with limited incentive to fund or engage in such a study. Furthermore, processes such as the National Environmental Policy Act and the statewide planning and metropolitan planning organization processes do not have explicit planning requirements for disinvestment, but rather they simply allow disinvestment to occur as a result of limited funds, focusing only on the investment and not the disinvestment outcome.

For this reason, while the economic tools and techniques are available [and as demonstrated by the ASCE study (ASCE 2011), the Washington State Department of Transportation (DOT) case example (J. Milton and P. Morin, personal communication, 2014) and others], and such tools can be arranged to develop and analyze disinvestment cases, the place for such analysis in the planning and policy environment is unclear. In addition to uncertainty regarding where in the policy environment disinvestment analysis belongs, there is the added challenge of establishing a most effective practice for creating and comparing disinvestment scenarios, and the investment of staff time and budgets into building the capacity for disinvestment. Finally, a major impediment to fully utilizing available techniques for disinvestment planning rests with the dimensions of a disinvestment scenario.

Agencies must address uncertainty on multiple dimensions in order to apply economic methods to disinvestment scenarios. These include:

1. Consideration of multiple possible demographic and economic futures and demand patterns;
2. Consideration of multiple possible scenarios for how life-cycle costs may change over an investment life;
3. Consideration of multiple sets of "minimum tolerable conditions" or performance standards for assets which might apply in each possible demand scenario; and
4. Consideration of the risk and likelihood associated with these different scenarios coming to fruition.

These dimensions require more time, effort, and know-how than the earlier investment or asset management paradigms of the 20th century. Disinvestment analysis requires significant time, attention, and know-how that is not present in most state DOT environments. The complexity of the problem poses a significant challenge to widespread adoption of economic analysis for disinvestment planning in the near term.

Key Gaps in Methods, Data, and Tools

The largest gaps in methods, data, and tools pertain to the appropriate application and internally consistent use of available methods and tools. Additional research is needed to:

- Identify possible sources of error that may arise when the different types of models needed to assess a disinvestment outcome are combined.
- Develop a widely accepted structure for how the multiple dimensions of disinvestment planning can be reduced to manageable base cases and performance standards that lend themselves to routine analysis in the planning environment.
- Identify ways to automate the links between needs (or asset management) models, travel demand models, socioeconomic/land-use forecasting models, cost–benefit analysis models, and economic impact models such that they can be routinely applied to disinvestment scenarios; and
- Assemble meaningful case studies of actual outcomes of transportation disinvestment outcomes in different circumstances.

A gap that cannot be covered by additional research, but that should inform how any findings are implemented, is in the financial and staff capacity of agencies to invest in the most state-of-the-art data, models, and information systems. In the same way, the degree to which agencies can establish consistency of decision methods for both investment planning and project programming is likely to enhance the degree to which agencies can benefit from assessing disinvestment scenarios.

Promising Approaches and Suggested Most Effective Practice

Although the current synthesis finds that there is not yet a recommended most effective practice for assessing the economic implications of disinvestment scenarios, there are promising approaches and practical steps that agencies can take to better support considering disinvestment scenarios. Perhaps first and foremost, the current synthesis finds that it is a more effective practice to explicitly consider disinvestment as a pro-active alternative for managing costs than to simply allow it to happen as an accident of limited funding.

Figure 8 suggests a way in which existing demand, risk, needs, and economic models may be combined to both prevent and anticipate future disinvestment situations in long-range planning.

It can be noted that Figure 8 may be a simplification in that another round of risk and probability modeling may be appropriate to assess not only best and worst case scenarios for demand, but also best and worst case scenarios of need within any given estimate of demand (because of differences in minimum tolerable conditions or infrastructure deterioration rates).

By developing a realistic disinvestment case, associated with a realistic assessment of the likelihood of changing needs, an agency can more effectively avoid unintended consequences of passive disinvestment. Furthermore, in many cases a disinvestment scenario may represent the "ounce of prevention" that is better than a "pound of cure." For example, if an agency can identify a need to disinvest in a facility or program to save life-cycle costs in the long term, the agency may be able to make the choice at a time when there is an option for a short-term investment in the re-use of the facility and the preparation of an alternative facility more appropriate to different future demands. In this way, agencies may use disinvestment planning to reduce both the risk of "sunk costs" in assets that ultimately become unsustainable and opportunity costs of other assets that cannot be afforded by maintaining all assets at original performance standards. This points to a need for future research regarding how agencies can build the capacity to identify these

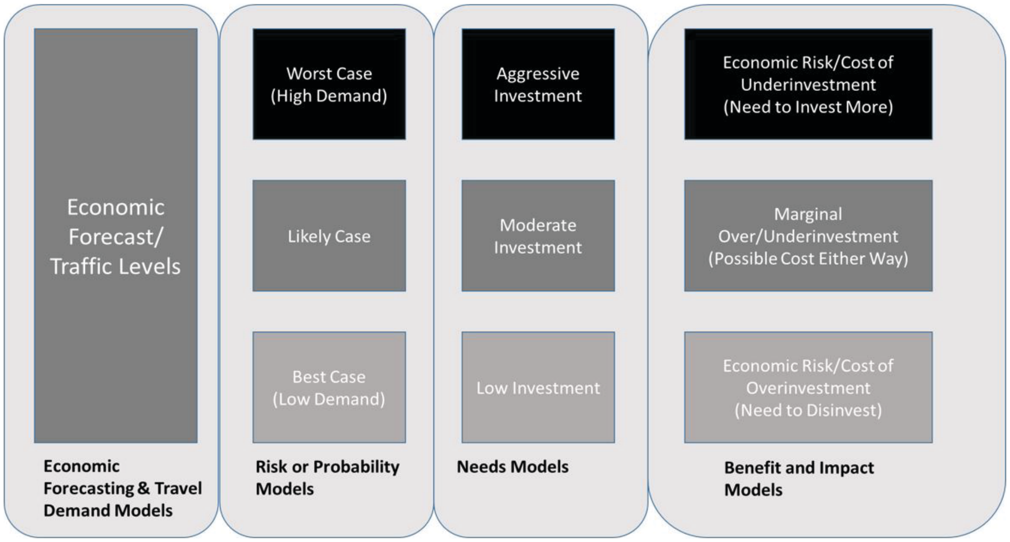


FIGURE 8 Role of different model types in disinvestment scenarios.

opportunities, as well as the data and technical needs for agencies to consistently identify and address disinvestment. The needed capacity building likely involves not only addressing the gaps enumerated in the previous section, but also clearly demonstrating how methods and data can most effectively be structured in a typical planning or analytical process.

Arriving at a paradigm in which states can consistently and reliably include disinvestment as part of their performance-based planning will likely take years of capacity building and further incorporation of basic economic methods and tools, as well as disinvestment concepts into the DOT business process. Some early steps in this regard include:

1. In performance-based plans, offering at least two different performance standards for each facility (such as a high-demand target and a low-demand target), such that different needs estimates may apply.
2. Considering the comparative return on investment for all projects and programs, taking into account both life-cycle costs and user costs under different future demand assumptions.
3. In long-range plans, considering both investment and disinvestment options, or scenarios that sustain different programs and assets at different levels (that may exceed or be less than historic levels).
4. In travel model development efforts, including at least two different socioeconomic forecasts to allow for two different traffic forecasts.

AREAS FOR FUTURE RESEARCH

It can be suggested from this synthesis report that a more comprehensive research effort be undertaken to develop instructive case examples demonstrating:

1. How a typical disinvestment economic analysis can be structured (through a series of case examples) showing how the base case, investment case, and disinvestment case can be defined, and key data elements required.
2. How both the scale and time horizon of the analysis period can significantly affect the results pertaining to both the need for infrastructure and the potential implications of disinvestment.
3. How available needs models, network and demand models, risk models, and impact models can be assembled in practical ways to assess a disinvestment scenario.
4. How an economic analysis of a disinvestment case differs depending on the available data and modeling resources and the scale of the project.
5. Ways in which appropriate analysis of disinvestment scenarios may yield insights regarding opportunities posed by resource constraints.
6. The likely magnitude of economic benefits and impacts that can result from the current practice of "tolerating underinvestment" in contrast to potential results of identifying and planning for disinvestment when needed.

GLOSSARY OF TERMS AND ACRONYMS

TERMS

Abandonment is the act of relinquishing an asset entirely and regarding the infrastructure investment as a "sunk cost" with the possible exception of the salvage value of the land.

Adaptive re-use is a tactic of redesigning or redesignating a piece of infrastructure formerly used for one purpose so that it can be used for a different purpose (at a lower cost). The "Rails to Trails" re-use of railroad right-of-way is an example of this. Adaptive re-use may be a source of benefits in a disinvestment situation.

Base case in an economic analysis is the scenario that assumes there is no change from the current investment pattern.

Deficiency is an observed level of performance that falls below an agreed standard or target.

Demand models are models that predict the future utilization of the transportation system and drive the assessment of needs. Demand models can be helpful for understanding how future demand may respond to a disinvestment situation. Errors in these models can lead to overinvestment or underinvestment in transportation systems, and may account for some disinvestment situations.

Direct economic impacts. The direct and wider transportation impacts (#1 and #2) will translate into changes in business operating cost, business productivity (returns from deployment of vehicles, as well as effects on inventory levels), and household expenditure patterns.

Direct transportation impacts. Disinvestment can lead to speed slowdowns, road/bridge/viaduct closures, or vehicle size/weight restrictions, all of which can lead to changes in traffic volumes, speeds, and routings—which show up as vehicle-miles traveled and vehicle-hours traveled changes. Reductions in the quality of pavement can also lead to changes in vehicle damage rates.

Disinvestment. A process by which an infrastructure asset (which may be a specific facility, a program, or a network) is allowed to fall below previously accepted standards of condition or performance by either investing resources elsewhere or simply not investing resources in the disinvested asset. This may also include choosing not to invest in new infrastructure or assets as needed to maintain an accepted level of performance on an existing facility or system.

Disinvestment scenario is a situation where an agency faces a choice about where and how much it will disinvest or channel investment away from one set of assets, programs, or priorities in order to support others.

Disinvestment situation is a situation where an agency has to make decisions that may entail accepting a level of performance that had previously been considered deficient. It is a situation where the agency must either lower its performance standard or increase its investment level to more than what it has been able to achieve historically.

Economic development is the process by which a state, regional, or local economy's use of human, natural, and other resources evolves to create a given standard of living and effective role within the larger economy.

Economic impact models translate economic performance outcomes found by needs models into dollar terms and identify how these dollars of economic loss or benefit are experienced in the economy. Impact models can be helpful for describing both the long-term effects of disinvestment and the effects of investment levels that are either too high or too low.

Intentional disinvestment. A conscious policy choice to disinvest in an infrastructure asset in order to make funds available elsewhere, or to manage funding shortfalls.

Investment (or disinvestment) case in an economic analysis is the scenario that assumes some change from the current investment pattern. In the case of intentional disinvestment it may represent a change in performance standard for a given program or asset, the transition of demand to an alternate facility, or the costs and economic outcomes anticipated from retrofitting the disinvested asset for some other use.

Investment gap is the dollar amount that would have to be invested above and beyond currently budgeted amounts to achieve minimum tolerable conditions for all assets over a period of time. Intentional disinvestment reduces an investment gap by lowering minimum tolerable conditions, whereas passive disinvestment allows the gap to grow while still holding an intention to somehow "catch up."

Jurisdictional turnback is a tactic of a federal or state agency giving an asset to a county or municipal unit of government, making it effectively no longer a part of the state or federal transportation system. While a turnback is not always a form of disinvestment (it may simply change the investing agencies), turnbacks can lead to disinvestment when they are accompanied by changes in classification or intended use for a facility.

Minimum tolerable conditions are an asset management term used to describe the condition or performance below which an asset is considered to be "deficient" and needing additional investment to perform properly. These usually consist of pavement conditions, bridge ratings, volume-to-capacity ratios, or intersection level of service. Intentional disinvestment lowers minimum tolerable conditions in order to reduce the needed investment level.

Needs models assess in dollar terms the amount of investment required to maintain a target level of system performance under any given demand forecast. Needs models can be helpful for understanding the performance implications of disinvestment. Uncertainty in needs models can lead to overinvestment or underinvestment, contributing to disinvestment situations.

Passive disinvestment. A policy choice (or series of policy choices) that, while not intended to allow an infrastructure asset to fall below previously accepted standards of condition or performance, effectively has such an effect over time.

Programmatic investment strategy is a planning strategy that considers different possible revenue allocations among programs to minimize the adverse economic implications of investment gaps in various programs. A programmatic investment strategy may also compare the economic implications of additional taxes, tolls, or user fees against the economic implications of investment gaps in transportation programs. Disinvestment scenarios may have a role in a programmatic investment strategy.

Risk models are models that assess the likelihood that any given scenario will occur, given certain underlying assumptions about existing and future conditions. Risk models are important for understanding the likelihood of positive or negative outcomes resulting from disinvestment.

Real option is the right, but not the obligation, to buy or sell an asset under specified terms. Real options may represent policy instruments or investments that agencies can make to enable future disinvestment to be made more efficiently and also to prevent premature investment (thereby preventing a future disinvestment situation).

Underinvestment is any revenue or budgetary policy that allows some investment gap in any given year for any given reason. Underinvestment over time may become passive disinvestment if conditions deteriorate so much that the agency could never afford to catch up or achieve its desired performance levels.

Wider economic impacts. The direct economic impacts (#3) can lead to wider economic impacts on transportation and production efficiencies (through cost impacts), supply chain and logistics technologies (through reliability and intermodal connectivity impacts), and business agglomeration opportunities (through regional accessibility impacts).

Wider transportation impacts. The direct transportation changes (#1) can affect the set of available links, their volume/capacity ratios, and vehicle size or weight limits, all of which can lead to changes in reliability, accessibility, and intermodal connectivity.

ACRONYMS

DOT—Department of transportation
HPMS—Highway Performance Monitoring System (database)
HERS-ST—Highway Economic Requirements System for States (pavement needs model)
LRTP—Long Range Transportation Plan
MAP-21—Moving Ahead for Progress in the 21st Century (national transportation law)
MPO—Metropolitan planning organization
NBI—National Bridge Inventory (database)
NBIAS—National Bridge Inventory Analysis System (bridge needs model)
NPS—National Park Service
NTD—National Transit Database
REMI—Regional Economic Models Incorporated (economic impact model)
RPO—Rural or regional planning organization
STIP—State Transportation Improvement Program
TEA-21—Transportation Equity Act for the 21st Century (national transportation law)
TERM—Transit Economic Requirements Model (transit needs model)
TIP—Transportation Improvement Program
TREDIS—Transportation Regional Economic Development Information System (economic impact model)

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APPENDIX A

Case Example Description of Screening Criteria and Discussion Guide

CASE SELECTION

Case examples were drawn first from survey respondents who indicated their agency had undertaken an intentional disinvestment situation and were willing to provide further details in an interview. Additional potential cases were identified by means of a search of existing material on agency websites and outreach to experts in the field. Once a potential case was identified, the research team made initial points of contact to determine whether the selected agency was willing to participate in an interview process and, if successful, conducted the appropriate interviews.

The cases were selected to include a diversity of planning environments and types of disinvestment. The following general profiles served as a guide for selecting case examples:

1. Intentional disinvestment in a **specific facility** where anticipated **outcomes were considered** and can be compared with actual outcomes.
2. Intentional disinvestment in a **corridor, network, or program** where **anticipated outcomes were considered** and can be compared with actual outcomes.
3. Intentional disinvestment in a **specific facility** where decision makers were **unable to anticipate outcomes,** but had to make the decision based on available information.
4. Intentional disinvestment in a **corridor, network, or program** where decision makers were **unable to anticipate outcomes**, but had to make the decision based on available information.
5. Passive disinvestment (through deferred maintenance or simple lack of resources) where **outcomes have appeared in other performance measures.**
6. Passive disinvestment (through deferred maintenance or simple lack of resources) where planners or decision makers are benchmarking deteriorating conditions, but **unsure what the economic implications are.**

It was generally not possible to select a case to reflect each of the situations described above. Nevertheless, every effort was made to select cases that reflected the range of indicated dimensions of disinvestment with respect to:

- Intentionality of the disinvestment scenario
- Scope and complexity of the asset or system experiencing the disinvestment
- Analysis available and applied to anticipate outcomes
- Retrospective understanding of outcomes (or potential to understand outcomes), whether anticipated or not.

DISCUSSION GUIDE

The following guide was used to direct the interview conducted for each case example. Allowances were made for the particular details of the case at hand, while still addressing each of the primary areas of interest.

- **Circumstances and context**
  – How did the situation/decision come up?
  – When?
  – Who was involved?
- **Defining disinvestment**
  – Describe, in your own words, why you think of this as a disinvestment
- **The decision process**
  – What options were considered, and how were they identified
  – Were there tradeoffs considered? If so, how were they managed?
  – Were economic implications of the decision taken into account? How?
- **Scrutiny of the decision**
  – What type of scrutiny did you get for the decisions and to whom were you accountable?
- **Confidence in assessment methods**
  – What kind of information was helpful or would have been helpful in understanding the economic implications of the decision?
  – Was there anything in particular that you wanted to understand but could not about economic implications in making the decision? What would have helped (data, methodology, etc.)?
- **If the decision has already been implemented . . .**
  – Do you think you anticipated economic (or other) outcomes correctly?
  – Were there any unanticipated outcomes (complaints, issues, etc.)?
  – Or perhaps the implications are still hard to understand, even after the fact?
- **Learning from experience**
  – What could others learn from your experience?
  – Were there any models/data sources/other resources that you found particularly helpful in your decision process that could be of use to others in similar situations?

APPENDIX B

Descriptive Summary of Survey Results

Q1. Has your agency made an intentional disinvestment choice in the last five years?

	Count	Percent
Yes	18	43.9%
No	18	43.9%
Responded: does not deal with issue/no information	5	12.2%

Total Responses: 41

Q2. What type of asset did the intentional disinvestment choice address (check all that apply)?

	Count	Percent
Disinvestment in a specific facility (roadway segment or bridge)	10	50.0%
Disinvestment in an entire corridor or sub-area	3	15.0%
Disinvestment in an entire program or class of roads	14	70.0%

Total Responses: 20

Q2. Other: If in a specific facility, briefly describe:

ID55 Bridge just north of Cascade, ID—Unanticipated scour led to weight restrictions
Primarily low use redundant bridges on local roads
Temporary closure of six rest areas
The disinvestment was in capacity expansion investments and an urban corridor.
The maintenance of roadway adjacent condition—grass cutting along the highways
Local road no longer serving as state highway
Due to funding restrictions, shortfalls, the need for prioritization of resources and other political needs, a disinvestment may occur on a particular facility or project.
Carpool parking lot, state-funded programs, scoping, advance right-of-way (ROW) purchases, wetland mitigation and rest area investment have been significantly reduced to focus on larger assets such as pavement and bridges.
Recommendations are made for pavement and bridge work. Funding will not fully support recommendations. After a level of deterioration we remove it from the initial list and recommend a more intensive treatment in a future year.
The Department has an $8.5 billion backlog of specific facilities that are currently unable to be funded. Choices are made each year when we develop our three-year work program to decide which facilities get funded and which do not.

Total Responses: 10

Q3. In the last five years, could your agency's intentional disinvestment choices be characterized more as: a) a single disinvestment choice for a particular facility; b) multiple periodic disinvestment choices in different facilities, programs, and services; c) a long-term, gradual process of "wholesale disinvestment" of entire programs or systems (which may have occurred incrementally) in the last five years

	Count	Percent
a) A single disinvestment choice	3	15.8%
b) Periodic disinvestment choice	4	21.1%
c) Wholesale or incremental disinvestment policy	12	63.2%

Total Responses: 19

Q4. What was the process by which your agency made the disinvestment choice (check all that apply)?

	Count	Percent
Programmatic investment (choice in long-range planning process)	4	20.0%
Prioritization decision in long-range planning process	6	30.0%
Prioritization decision in the STIP/TIP process	11	55.0%
In response to budget cuts from elected entities (governor or elected body)	4	20.0%
Directed to disinvest in a specific facility or program by an elected entity	1	5.0%
Part of an agreement with another unit of government (jurisdictional turnback or mutual disinvestment decision)	4	20.0%
Other (specify):	5	25.0%

Total Responses: 20

Q4. Other

Cash flow, not enough state revenue to support state-funded initiatives
In response to projected budget shortfalls
Limited the scope of improvements on lower function highways
Suspend CMAQ and TE program
Investment planning process in consultation with department leadership and the State Transportation Commission.

Total Responses: 5

Q5. What were the criteria or reasons for the disinvestment (check all that apply)?

	Count	Percent
Insufficient funds to support the asset	15	75.0%
Concerns about the risk associated with partially maintaining an asset in a condition less than its original design or function. (1)	3	15.0%
Other investment needs were deemed more important	16	80.0%
Asset no longer needed or used	1	5.0%
Asset replaced by another, different mode or facility	1	5.0%
Asset had safety, environmental, or other costs too high to justify its transportation function	5	25.0%
Other (specify):	4	20.0%

Total Responses: 20

Q5. Other

Preservation was deemed more important than facility expansion.
Maximizing system health
Reduction of expenses to a new level of acceptable performance
Our state is a pay as you go state. Our department also a "fix it first" policy to make sure the current system is maintained. Efforts are made to distribute the limited funding across the regions and between urban and rural communities. Project disinvestment usually occurs because of a lack of funding in various federal and state fund codes.

Total Responses: 4

Q6. What was the nature of scrutiny (public/external versus agency/internal) pertaining to the intentional disinvestment decision?

	Count	Percent
Mostly Internal (within the agency) = 5	6	30.0%
Mostly Internal with Some External = 4	7	35.0%
Equally Internal and External = 3	6	30.0%
Mostly External = 2	1	5.0%
Not Scrutinized = 1	0	0.0%

Total Responses: 20
Average: 3.90

Q7. What degree of public scrutiny did the agency receive pertaining to the intentional disinvestment decision (check one)?

	Count	Percent
Heavily Scrutinized = 5	3	15.0%
Somewhat Scrutinized = 4	4	20.0%
Same Scrutiny of Any other Investment Decision = 3	5	25.0%
Small Degree of Scrutiny = 2	7	35.0%
Not Scrutinized = 1	1	5.0%

Total Responses: 20
Average: 3.05

Q8. What level of stakeholder involvement was involved in the intentional disinvestment decision?

	Count	Percent
Structured public outreach to obtain input and explain decision = 5	7	35.0%
Structured outreach to explain decision only = 4	7	35.0%
No structured outreach, but explained decision through media/website = 3	2	10.0%
Required legal hearings only = 2	1	5.0%
No stakeholder involvement = 1	3	15.0%

Total Responses: 20
Average: 3.70

Q9. What level of involvement from businesses and economic development entities was included in the disinvestment decision?

	Count	Percent
Actively involved through structured outreach targeted to business and economic development community	1	5.3%
Actively involved through unstructured collaboration (individual meetings, phone discussions, and other informal input)	4	21.1%
Involved within the context of other stakeholder outreach, but none specifically to business/economic development community	7	36.8%
Required legal hearings only	0	0.0%
No business/economic development involvement	7	36.8%

Total Responses 19

Average: 2.58

Q10. What types of analysis did your agency perform to anticipate the potential economic/business effects of disinvestment (check all that apply)?

	Count	Percent
Cost-benefit analysis using a spreadsheet	3	15.0%
Cost-benefit analysis using an asset management tool that predicts asset conditions (such as HERS-ST or NBIAS)	2	10.0%
Cost-benefit analysis using an online model	0	0.0%
Economic Impact Analysis (using a model like REMI, TREDIS, etc.)	2	10.0%
Consulting historical data on asset performance (traffic counts, safety, pavement condition, bridge rating, etc.).	13	65.0%
Consulting data about the improvement history and cost of the asset (frequency and magnitude of maintenance or preservation investments), etc.	10	50.0%
Consulting spatial or statistical data about asset utilization (traffic counts, percent trucks, network origin-destination patterns)	7	35.0%
Identifying analogous disinvestments in other areas	0	0.0%
Interviewing or surveying businesses and economic development entities about their anticipated responses	1	5.0%
We did not conduct analysis to anticipate the economic implications	5	25.0%
Other (specify):	5	25.0%

Total Responses: 20

Q10. Other

Decision Lens 3 software for project prioritization
dTIM asset management model
Performed cash flow analysis to determine that we could support planned and ongoing activities
Consulted with businesses, developers, and local elected officials to discuss the potential economic/business effects of the disinvestment.
Considered truck counts, available private truck parking options and available traveler services, spacing between rest areas, cost to maintain, age/condition of facility

Total Responses: 5

Q11. If used, How confident are you that the findings of these analysis methods adequately enabled you to anticipate the economic effects of disinvestment?

	Highly Confident = 4 (%)	#	Somewhat Confident = 3 (%)	#	Not Confident = 2 (%)	#	Did Not Use = 1 (%)	#	Total Responses	Average
Cost-benefit analysis using a spreadsheet	9.1%	1	27.3%	3	0.0%	0	63.6%	7	11	2.25
Cost-benefit analysis using an asset management tool that predicts asset conditions (such as HERS-ST or NBIAS)	18.2%	2	9.1%	1	0.0%	0	72.7%	8	11	2.67
Cost-benefit analysis using an online model	0.0%	0	0.0%	0	0.0%	0	100.0%	10	10	-
Economic impact analysis (using a model like REMI or RIMS or TREDIS)	10.0%	1	0.0%	0	0.0%	0	90.0%	9	10	3.00
Consulting historical data on asset performance (traffic counts, safety, pavement condition, bridge rating, etc.).	28.6%	4	50.0%	7	7.1%	1	14.3%	2	14	2.25
Consulting data about the improvement history and cost of the asset (frequency and magnitude of maintenance or preservation investments), etc.	15.4%	2	61.5%	8	7.7%	1	15.4%	2	13	2.09
Consulting spatial or statistical data about asset utilization (traffic counts, percent trucks, network origin-destination patterns)	33.3%	4	41.7%	5	0.0%	0	25.0%	3	12	2.44
Identifying analogous disinvestments in other areas	0.0%	0	0.0%	0	0.0%	0	100.0%	10	10	-
Interviewing or surveying businesses and economic development entities about their anticipated responses	0.0%	0	20.0%	2	0.0%	0	80.0%	8	10	2.00
Other (previously specified)	12.5%	1	25.0%	2	0.0%	0	62.5%	5	8	2.33

Q12. If you could have had any types of data, tools, or methods available to you to assess likely impacts of the disinvestment decision, *how desirable* would the following models or tools be?

	Highly Confident = 3 (%)	#	Somewhat Confident = 2 (%)	#	Not Desirable = 1 (%)		Total Response	Average
Cost-benefit analysis using a spreadsheet	36.4%	4	36.4%	4	27.3%	3	11	2.09
Cost-benefit analysis using an asset management tool that predicts asset conditions (such as HERS-ST or NBIAS)	69.2%	9	30.8%	4	0.0%	0	13	2.69
Cost-benefit analysis using an online model	36.4%	4	36.4%	4	27.3%	3	11	2.09
Economic impact analysis (using a model like REMI or RIMS or TREDIS)	41.7%	5	58.3%	7	0.0%	0	12	2.42
Consulting historical data on asset performance (traffic counts, safety, pavement condition, bridge rating, etc.).	54.5%	6	45.5%	5	0.0%	0	11	2.55
Consulting data about the improvement history and cost of the asset (frequency and magnitude of maintenance or preservation investments), etc.	50.0%	5	50.0%	5	0.0%	0	10	2.50
Consulting spatial or statistical data about asset utilization (traffic counts, percent trucks, network origin-destination patterns)	54.5%	6	45.5%	5	0.0%	0	11	2.55
Identifying analogous disinvestments in other areas	18.2%	2	63.6%	7	18.2%	2	11	2.00
Interviewing or surveying businesses and economic development entities about their anticipated responses	30.0%	3	50.0%	5	20.0%	2	10	2.10
Other (previously specified)	0.0%	0	28.6%	2	71.4%	5	7	1.29

Q13. How confident are you that you adequately anticipated the economic implications of disinvestment?

	Count	Percent
Very Confident = 3	4	20.0%
Somewhat Confident = 2	8	40.0%
Not at All Confident = 1	8	40.0%

Total Responses: 20

Average: 1.80

Q14. If you did not undertake any analysis to anticipate the economic effects of the disinvestment choice, why was such analysis not undertaken?

	Count	Percent
Limited time, budget, and staff availability	7	58.3%
Concerns about political implications of findings	2	16.7%
Lack of confidence in available methods and tools	3	25.0%
Stakeholders, agency, or political leadership did not scrutinize decision/analysis would not have affected decision	6	50.0%

Total Responses: 12

Q15. Has your agency ever gone back and performed an evaluation to assess the potential economic effects of an earlier disinvestment choice?

	Count	Percent
Yes, we have performed this type of assessment	3	15.8%
No, but we have been approached about, or have considered such assessments	9	47.4%
We have never considered such assessments	7	36.8%

Total Responses: 19

Q16. What indicators would you consider the most appropriate for assessing the economic implications of a disinvestment choice (check one level of usefulness for any methods that apply)?

	Highly Useful = 3 %	#	Somewhat Useful = 2 %	#	Not Useful = 1 %	#	Responses #	Average
Changes in transportation costs (including travel time, operating costs, reliability, safety or environmental costs) accruing to households and businesses	75.7%	28	24.3%	9	0.0%	0	37	2.76
Changes in the accessibility of households and businesses to key locations (such as, population within a 40-mile commuting radius of a business district or businesses within a same-day delivery radius of a key center of activity)	62.2%	23	37.8%	14	0.0%	0	37	2.62
Changes in household or business locations	25.7%	9	62.9%	22	11.4%	4	35	2.14
Changes in property values	22.2%	8	55.6%	20	22.2%	8	36	2.00
Complaints from stakeholders	36.1%	13	55.6%	20	8.3%	3	36	2.28
Other	36.4%	4	18.2%	2	45.5%	5	11	1.91

Q16. Other:

Traffic counts
Future costs of asset replacement
Loss of asset value
Return on investment. Effects on future revenue both for transportation agency and state and local government.

Total Responses: 4

Q17. If your agency has not made an intentional disinvestment choice, how do you (or would you) determine that an unintentional disinvestment has occurred?

	Count	Percent
Consistent funding levels below assessed investment needs	24	77.4%
Benchmarking condition or performance, and consistently performing below target performance levels	26	83.9%
Publicly visible performance failure (bridge collapses, road gridlocked, etc.)	20	64.5%
Complaints from business or economic development community	17	54.8%
Complaints from stakeholders or elected leaders	17	54.8%
Other (specify):	3	9.7%

Total Responses: 31

Q17. Other

Several of these events have occurred in our example
I didn't check the first option because that is standard operating—there are never enough funds available to meet all of the needs. So—an alternative response might be an increasing gap between funding needed to maintain system investment needs and funding available for investment.
Unintentional disinvestment has occurred if it is defined as not making investments because of insufficient revenues.

Total Responses: 3

Q18. If your agency has experienced unintentional disinvestment, why have investment levels or asset conditions reached a point of disinvestment (as evidenced by the indicators given in your answer to question 17)? Check all that apply.

	Count	Percent
Recurring funding shortfalls and deferred investment led to condition where the costs of 'catching up' seem insurmountable in any given budget cycle.	20	71.4%
Asset deteriorated at a rate faster than anticipated by budgeting, planning, and programming models.	10	35.7%
Demand for asset increased at a rate faster than anticipated by budgeting, planning, and programming models.	11	39.3%
Asset condition or performance not properly understood when funding decisions made.	7	25.0%
Other (specify):	4	14.3%

Total Responses: 28

Q18. Other

In our bridge example, unexpected scour occurred
Insufficient revenues
Funding levels are not sufficient to overcome the effects of inflation and materials cost escalation over the long term. As inflation erodes revenue and assets age, the condition declines slowly, but steadily.
I'm not sure that we've experienced unintentional disinvestment; we are achieving our performance goals. However, our system performance charts are on a downward trend, which may be the result of intentional disinvestment due to expanding gap between needs and resources or we might be coming off of a high point in system performance as a result of the additional system improvements from the investment of unanticipated ARRA funds.

Total Responses: 4

Q19. When allocating resources in your planning and capital programming process, are the implications of both investment and disinvestment considered in assessing points or quantifying the benefits of competing projects/programs?

	Count	Percent
The benefits of investment are considered, but the costs of disinvestment are assumed to be limited only to the foregone benefits of investment. = 5	16	43.2%
Both the benefits of investment and costs of disinvestment are considered, but the benefits of investment factor more heavily. = 4	10	27.0%
Disinvestment costs and investment benefits considered equally. = 3	9	24.3%
Both the benefits of investment and the costs of disinvestment are considered, but the costs of disinvestment factor more heavily. = 2	1	2.7%
The costs of disinvestment are considered, but the benefits of investment are only understood to be the foregone costs of disinvestment = 1	1	2.7%

Total Responses: 34

Average: 4.05

Q20. What would most help your agency in understanding and articulating to stakeholders the likely economic implications of a disinvestment decision? Check all that apply.

	Count	Percent
More data about asset conditions, performance, and utilization	20	54.1%
More case examples of outcomes that have occurred as a result of disinvestment in comparable circumstances	23	62.2%
Better models to predict economic outcomes of disinvestment	27	73.0%
Better models to predict the implications of disinvestment on transportation performance measures	24	64.9%
Better ways to elicit input from businesses about how they will respond to a disinvestment choice	16	43.2%
Other (specify):	2	5.4%

Total Responses: 37

Q20. Other

Better methods to estimate the opportunity costs of disinvestment
Question 19 and 20 are difficult to answer. We approach our allocation process to provide the right treatment at the right time, to avoid overinvesting or underinvesting in a particular area. The cost of disinvestment could end up being facility replacement cost rather than maintenance costs—so it is the driving factor in our approach. I think we have communicated this to our stakeholders pretty well. For a direct response to #20, I'd say that showing the stakeholders the future cost of not investing today (in performance and cost to restore condition).

APPENDIX C

Future Research Needs

AASHTO STANDING COMMITTEE ON RESEARCH AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

I. PROBLEM NUMBER

To be assigned by NCHRP staff.

II. PROBLEM TITLE

Best practices for assessing economic implications of disinvestment or right-sizing scenarios.

III. STATEMENT OF THE RESEARCH PROBLEM

In an era of constrained funding, as the transportation system ages, successive generations of users present different patterns of demand, performance requirements and transportation needs from those for which infrastructure was originally designed. Federal, state, and regional agencies are often faced with balancing the perceived need to invest in new emerging demands with the need to maintain long-standing assets. Significant research has been done into the topic of identifying transportation investment needs, return on investment, and prioritization. However, the body of research has not clearly demonstrated a best practice or methodology for scenarios that involve “right-sizing” (determining and implementing the optimal sustainable investment level), re-using or disinvesting in existing assets and programs to support more efficient uses or priorities. The result has been a pattern of passive disinvestment by many agencies, which respond to budget shortfalls by simply investing in the highest priority projects to find that over time they are unable to “catch up” with long-term investment shortfalls. This creates a situation of “disinvestment,” which poses both long-term performance challenges and economic inefficiencies.

While current models exist to assess transportation demand, risk, long-term needs, performance outcomes, and economic impact of transportation investments, no study has clearly demonstrated how these methods can be practically applied to consider right-sizing or disinvestment decisions. For example, typical planning scenarios today do not consider the economic risk of overinvestment versus underinvestment, or the potential impacts of a deliberate right-sizing scenario in comparison with an “unexpected shortfall” in revenue. A study is needed to clearly demonstrate how existing methods can be used to compare different investment and disinvestment economic scenarios while accounting for uncertainty and both the risk of over-build and under-build in the long-term.

The outcome of this research will be a series of practical examples applying currently available demand, risk, needs, and economic models to consider both the options and outcomes likely to arise from right-sizing or disinvestment situations. These examples and their associated methods should be readily transferrable to DOT’s MPOs, RPOs, and other agencies currently facing budget shortfalls and shifting demands. The nearly ubiquitous dilemma of ongoing budget shortfalls and competing demands between existing assets and emerging needs points to the urgency of this problem throughout the country. In addition to practically demonstrating how disinvestment and right-sizing scenarios can be addressed (both in the long-range planning and programming levels), the research is also expected to identify key gaps in research, data, and technology that can enable agencies to better address right-sizing and disinvestment situations in the long-term.

> **Special note to AASHTO committees and subcommittees:** Please indicate the relationship between the suggested problem and the committee’s strategic plan and/or its overall research agenda. If not related to a planned agenda, explain the urgency of the research need.

IV. LITERATURE SEARCH SUMMARY

NCHRP Synthesis 45-11: *Economic and Development Implications of Transportation Disinvestment* includes a current and exhaustive literature review on this subject. A full reference list is provided as an addendum to this research needs statement.

V. RESEARCH OBJECTIVE

The specific research objective of this statement is to demonstrate how existing data and tools can enable federal, state, and regional agencies to assess the economic implications of right-sizing or disinvestment decisions including the following aspects of such decisions:

1) Uncertainty and risks surrounding future demand forecasts
2) Uncertainty and risks surrounding investment future needs estimates
3) Discernment of optimal investment levels, such that a “right-size” of investment can be implemented and defended
4) Potential variation performance outcomes between best and worst case scenarios, and associated risk of over- or under-building (or over or under maintaining)
5) Assessment of economic costs and impacts of over-investing (or over-maintaining) versus under-investing (or under-maintaining)
6) Consideration of the relative efficiency of implementing a right-sizing or disinvestment scenario in contrast to the potential outcome funding simply failing to materialize for planned investments.

This research objective is envisioned to be achieved by selecting between 3 and 5 planning situations (either recent or current) on which to test existing methods for addressing the above 5 dimensions. It is expected that at least one will be a long-range multi-modal planning context (at the state or MPO level) considering investment levels in overall programs, and at least one will be a project-level prioritization or programming effort. The key steps to achieve the research objective include:

1) Developing screening criteria for selecting test areas (including assessing data availability, transferability to other similar areas, and the likelihood of enlisting the support of local planning organizations)

2) Obtaining key data and model results for assessing (1) future demand on the system; (2) likelihood of future demand occurring under best and worst case scenarios; (3) future investment needs based on demand (best and worst case); (4) likelihood and societal costs and economic impacts of different overinvestment, efficient investment, or underinvestment outcomes. At a minimum, the following model types and data sources are expected to be used, with more rigorous data sources and models used where available:
   a. 4-step travel demand models (in widely available platforms) or comparable forecasting techniques in the case of rural or un-modeled areas
   b. Asset Management or Needs Models (including HERS-ST, NBIAS, and TERM) using associated HPMS, NBI, and NTD data sources (and other more rigorous asset and needs forecasting models in cases where available and appropriate).
   c. Risk models that may utilize Monte-Carlo simulation, econometric methods, or other techniques (to be identified and justified as part of this task, beginning with the methods described in NCHRP 45-11)
   d. Economic benefit and impact models (that may include things like HERS-ST, StratBenCost, TREDIS-BC, REMI, and others).
3) Reporting these results in ways that demonstrate how this information can be applied by other agencies in shaping planning options and scenarios.
4) Discussion of transferability of results, new research gaps, and key agency capacity building needs for making the demonstrated methods practical at the national level.

If existing model runs of demand models, investment needs models, and risk models are actually in place for each of the selected planning situations, it may not be required for new modeling to be performed as part of this project. However, it is expected to be most likely that custom runs of demand, needs, risk, and economic models will be required, as the research will entail structuring and linking these types of models in a new way. Consequently the budget assumes that some modeling will be done as part of the research (using data and models available from the 3 to 5 agencies used as test cases).

VI. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

Recommended Funding: The recommended funding for this research project is $500,000, which is to include all services associated with fully implementing the research (including modeling and data acquisition), the purchase of any private or syndicated data or models (including economic impact models and associated data sets), and development and presentation of the final report. The funding level could vary from $300,000 to $500,000 depending on the number of pilot scenarios included (between 3 and 5 scenarios).

Research Period: It is estimated that 24 months should be allowed for this research to allow sufficient time to identify appropriate pilot scenario cases and to allow agency staff in the supporting agencies to provide needed models and data, and where possible to synch the test cases with their actual planning and decision-making processes.

VII. PERSON(S) DEVELOPING THE PROBLEM

Chandler Duncan, Senior Associate, EDR Group, 155 Federal St., Boston, MA 02110 (617) 338-6775 x203 cduncan@edrgroup.com

VIII. PROBLEM MONITOR

TBD

IX. DATE AND SUBMITTED BY

TBD

Advice to state departments of transportation and the Federal Highway Administration: Submitters are encouraged, but certainly not required, to vet or submit problem statements through an appropriate AASHTO committee or subcommittee.

Please submit completed problem statement to the following e-mail address:

nchrp@nas.edu

Questions on the process can be directed to the same address or cjencks@nas.edu.

Abbreviations used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

TRANSPORTATION RESEARCH BOARD
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