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SUSTAINABILITY PERFORMANCE MEASURES FOR STATE DOTS AND OTHER TRANSPORTATION AGENCIES

FINAL REPORT

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DISCLAIMER

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ABSTRACT

Many transportation agencies recognize the importance of sustainability—in terms of addressing concern for the environment, community health and vitality, and economic development, now and into the future. However, transportation agencies such as state departments of transportation often struggle to understand, measure, and apply sustainability concepts in their core activities. Using performance measures can help agencies achieve their goals with respect to sustainability. This project developed guidance for transportation agencies to understand and apply concepts of sustainability through performance measurement. The research team conducted a detailed literature review and a state-of-the-practice assessment including case studies and interviews with selected transportation agencies. A flexible, generally applicable framework was then developed to provide agencies with the tools required to apply sustainability in a holistic manner through performance measurement. The framework can be applied/adapted for use in a broad range of transportation agencies and at any level within such agencies. The framework directs an agency's strategic planning toward the practical implementation of sustainability through performance measurement, and encourages the coordination with partner agencies and stakeholders. The research also covered the various types of applications of sustainability performance measures, and identified specific examples, tools, and approaches to applying sustainability.

EXECUTIVE SUMMARY

INTRODUCTION AND RESEARCH APPROACH

The goal of National Cooperative Highway Research Program (NCHRP) Project 08-74 was to develop guidance for state departments of transportation (DOTs) and other transportation agencies to understand and apply concepts of sustainability through performance measurement. Even as many transportation agencies are recognizing the importance of sustainability, they often struggle to understand, measure, and apply sustainability concepts in their core activities.

As a first step, the research team developed an understanding of existing literature and the state of the practice with respect to sustainability, sustainability as applicable to transportation agencies, and performance measurement for sustainability. A state-of-the-practice review of various DOTs, metropolitan planning organizations, and transit agencies was conducted, followed by detailed case study interviews of selected agencies identified as being best-practice examples of sustainability implementation. The findings from the literature and case studies were used to gain a deeper understanding of how sustainability should be addressed by transportation agencies.

Following this, a framework for the application of performance measurement for sustainability was developed, which defined a set of guiding principles of sustainability and sustainability goals relevant to transportation agencies' functions. Further guidance on applying sustainability performance measurement in a context-specific manner was developed as part of this framework. In addition to this research report, a guidebook for transportation agencies was developed to provide user-friendly guidance on the implementation of the framework. The guidebook includes a spreadsheet-based electronic compendium of performance measures.

DEVELOPING A FRAMEWORK FOR SUSTAINABILITY PERFORMANCE MEASUREMENT

Typically, sustainability is considered a combination of economic, social, and environmental progress, achieved while meeting human needs in the present and the future. The economic, environmental, and social aspects are usually termed the dimensions of sustainability.

In approaching sustainability from a transportation agency perspective, there is a divergence between what is termed a *transportation-centered* view of sustainability and a more *holistic* view of sustainability. Each approach has relative merits and demerits—a holistic view necessitates looking beyond the transportation sector, which is necessary to truly address sustainability, but is potentially more difficult to implement than a transportation-centered approach. In this research, sustainability in transportation (or sustainable transportation) is addressed keeping in mind that transportation is one part of a larger system.

Therefore, this research defines a set of core principles of sustainability that are universal and not specific to the transportation sector. Sustainability entails meeting human needs for the present and future, while:

- Preserving and restoring environmental and ecological systems.
- Fostering community health and vitality.
- Promoting economic development and prosperity.

- Ensuring equity between and among population groups and over generations.

These principles form the basis of the approach to sustainability implemented in the framework.

Performance measures or indicators are being increasingly used by transportation agencies for a variety of purposes and can broadly be defined as measureable criteria that can be used to assess progress toward goals. Performance measures for sustainability (or sustainability performance measures) can be used to support progress toward sustainability goals and are increasingly being used in the transportation sector.

The framework for sustainability performance measurement application developed as part of this project uses the principles of sustainability as a starting point and recommends a hierarchy of goals, objectives, and performance measures, which are implemented as fundamental components of the framework. Additional components of the framework, termed auxiliary and overarching components, further supplement the core framework. Figure 1 presents a framework diagram. The following is a description of the basic framework components:

- **Fundamental components**—these elements are required for the step-by-step application of the framework, and include understanding sustainability; developing appropriate goals, objectives, and performance measures; and implementing the performance measures.
- **Overarching components**—these are elements that need to be considered throughout the framework application process, such as stakeholder involvement.
- **Auxiliary components**—these are related but optional components that can be used to supplement the framework application process, for example, the use of an organizational definition of sustainability or employee-based initiatives for sustainability.

The goals developed as a part of the framework are reflective of the principles but are relevant to the transportation sector. A set of 11 recommended goals are provided as part of this research. The objectives, which provide further specificity to the goals, are defined to be relevant to focus areas, which are generic classifications of a transportation agency's core functions—ranging from planning, programming, and project development, to construction, operations, and maintenance. The performance measures are directly tied to the objectives. This research also provides guidance on implementing the framework at any level of an agency or for units within an agency.

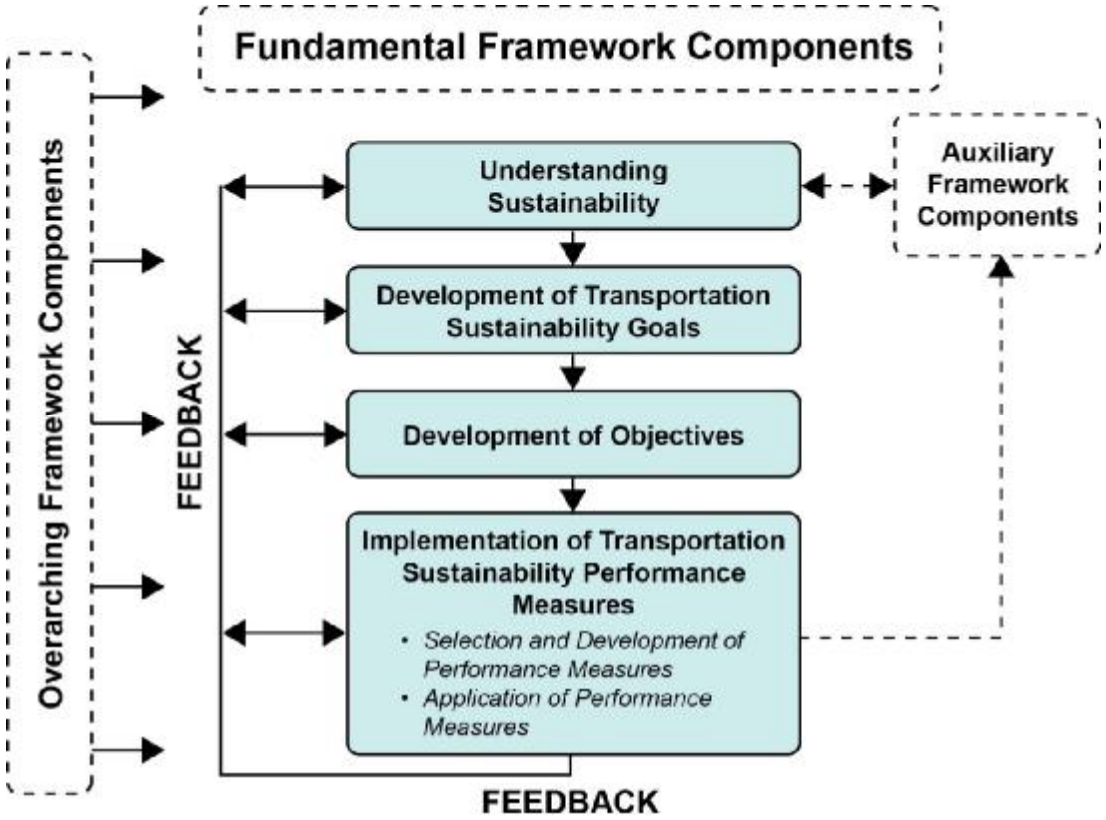

Figure 1. Simplified Framework Diagram.

DISSEMINATION OF RESEARCH FINDINGS

As the research progressed, the research team submitted journal papers, conducted workshops, and made presentations at conferences. The final products from this research include the final project report and the published guidebook. The presentation and workshop materials developed to date can also be used for information dissemination. Future avenues for dissemination identified include:

- Conference presentations, journal articles, and research papers.
- Transportation Research Board (TRB)–sponsored webinars and workshops.
- Training for state and other transportation agencies' staff and elected officials.
- Inclusion in university curricula as a teaching module for transportation planning/decision-making courses.
- Dissemination on websites/web-based communities.

CONCLUSIONS AND SCOPE FOR FUTURE RESEARCH

This project equips transportation agencies with background information on sustainability in the context of transportation, and the information and resources needed to successfully tailor and implement a sustainability performance measurement system. Therefore, this research provides the foundation for transportation agencies to address sustainability through performance measurement. During the course of the project, a set of research needs were identified that would

further enhance the application of sustainability in transportation agencies. These are classified into five broad themes:

- Improved tools, methodologies, and applications for sustainability performance measures for transportation agencies.
- Training and capacity building to facilitate implementation.
- Strategic planning for sustainability in transportation agencies.
- Integration of sustainability performance measurement in multiple sectors.
- Addressing the role of legislative and policy direction in promoting sustainability for transportation.

CHAPTER 1—INTRODUCTION

The goal of NCHRP Project 08-74 was to develop guidance for state DOTs and other transportation agencies to understand and apply concepts of sustainability through performance measurement to enhance their activities in areas such as planning, programming, project development, system operations, and maintenance. The purpose was to develop a guide that is flexible and can be used by a range of transportation agencies for specific contexts. The project objectives included:

- Conducting a survey of available literature, the current state of the practice, and detailed case studies to gain a deeper understanding of how sustainability should be addressed.
- Defining a set of guiding principles of sustainability and sustainability goals relevant to transportation agencies' functions.
- Developing a framework to address performance measures and outcomes at different levels, thereby creating an organized system for measuring the performance of transportation with respect to sustainability criteria.
- Compiling the research findings in the form of a guidebook that would help transportation agencies incorporate performance measurement for sustainability.

This two-year project consisted of the following tasks:

- Task 1—State-of-the-Practice Review.
- Task 2—Identify Best Practices.
- Task 3—Develop a Definition of Sustainability and a Draft Framework.
- Task 4—Technical Memorandum Summarizing Tasks 1 through 3.
- Task 5—Complete the Sustainability Performance Measure Framework.
- Task 6—Draft Guide for Framework.
- Task 7—Interim Report Summarizing Tasks 1 through 6.
- Task 8—Final Guide.
- Task 9—Venues/Methods for Disseminating Project Results.
- Task 10—Recommendations for Future Research.
- Task 11—Final Project Report.

This report documents work performed in this project, including the literature review, case studies, and approach and methodology for developing a framework for sustainability application. This report also discusses the development of a compendium of performance measures, guidance for transportation agencies to incorporate the sustainability performance measures, venues/methods for disseminating the project findings, and recommendations for future research.

In addition to this research report, there are two additional research products from this project, a user-friendly guidebook for transportation agencies (referred to as the guidebook) and a spreadsheet-based electronic compendium of performance measures (referred to as the compendium). Both the guidebook and compendium supplement the research findings documented in this report and are referenced where necessary. This report consists of five chapters. Following this introductory chapter, Chapter 2 covers the research context and state of the practice, including best-practice case studies. Chapter 3 discusses the development of a framework for sustainability relevant to state DOTs and other transportation agencies, and

Chapter 4 discusses the implementation of performance measures as envisioned in the framework. Chapter 5 provides conclusions and recommendations, including discussion of future research needs and avenues for dissemination of the project findings.

CHAPTER 2—CONTEXT AND STATE OF THE PRACTICE

This chapter covers the literature review and case studies conducted as part of the research project, which were used by the research team to frame the approach to sustainability in the appropriate context. In addition to works cited in the chapter (included in the References section), Appendices A through C provide supplementary information on additional literature, resources, case studies, and definitions.

BACKGROUND AND RESEARCH CONTEXT

A vast body of literature exists on the topics of sustainability, sustainable transportation, and performance measures. This background section references key literature and also discusses the research team's approach and framing of the research problem in the context of the existing literature. Appendix A lists an expanded bibliography and resources relating to sustainable development, transportation and sustainability, performance measurement, and performance measures for sustainability. As further background, Appendix B contains a glossary of terms related to sustainability and sustainable development.

This section summarizes key findings from literature and the research approach on the following topics:

- Sustainability and sustainable development.
- Sustainability in the transportation sector.
- Performance measures/indicators for sustainability.
- Context for applying sustainability in U.S. transportation agencies.

Sustainability and Sustainable Development

The issue of sustainability has been given increasing focus recently in almost every sector, ranging from private organizations/industries to a variety of government and public-sector entities. In general, sustainability can be thought of as relating to the holistic consideration of environmental, economic, and social concerns, with a long-term perspective. There is a significant amount of literature (mostly developed since the late 1980s) devoted to discussing sustainability and what it means as a concept. Often, in such research, the terms "sustainability" and "sustainable development" are used in similar contexts, and are used interchangeably in this report. The term "sustainable development" evolved to link two distinct yet related concerns—sustainability (fairness with respect to future generations' needs, i.e., preserving the Earth's natural life-support systems into the future) and development (more immediate concerns over progress and improvement in living conditions for the present) (*1*). The emergence of the terms "sustainability" and "sustainable development" into common usage can be traced through various global events, conferences, legislation, and publications (*2*, *3*). To this day, however, a majority of the work that discusses sustainability inevitably refers to the 1987 report for the United Nations World Commission on Environment and Development (commonly referred to as the Brundtland Commission report) (*4*). In this report, sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The report also defined strategic imperatives and preconditions for implementing sustainability and is considered a turning point in recognizing that sustainability needs to be addressed comprehensively through coordination among various sectors, and not with

a piecemeal approach (*5*). A reason for the popularity of the Brundtland definition of sustainability can be attributed to the fact that it presents a broad agenda that even entities with conflicting interests or goals can agree upon (*6*). However, the Brundtland work has been criticized as being too anthropocentric (i.e., too focused on human development and needs). Alternative eco-centric approaches include the Natural Step Approach framework (*7*), and the concept of natural capitalism (*8*), which views the natural environment as the primary focus of sustainability.

Sustainability Dimensions

The dimensions of sustainability (also termed the pillars of sustainability) are the environmental, economic, and social dimensions. The underlying understanding is that environmental, economic, and social systems are interconnected. If development is to be sustainable, it has to consider these dimensions comprehensively. This is termed a triple bottom line approach to sustainability. Many definitions of sustainability address these three dimensions: for example, "striving for an optimal balance between economic, social, and ecological objectives" (*9*) or "[sustainability]… requirements reflect that social conditions, economic opportunity, and environmental quality are essential if we are to reconcile society's development goals with international environmental limitations" (*10*). The dimensions do not represent isolated areas of human life but are more like metaphors for a comprehensive approach to judge if development is sustainable overall (*1*).

How the dimensions of sustainability are to be made operational and what their roles are in regard to one another are open to interpretation. Often, the dimensions overlap, and the issue of trade-offs between the dimensions has to be addressed. Conceptually, one way to relate the dimensions to one another is as a set of nested circles with the economic dimension being contained within the social dimension, which in turn is encompassed by the environmental sphere. This represents the view that economic systems are contained within a social framework; similarly, society exists within the natural environment. There are many alternative conceptual representations in published literature used to illustrate the linkages between the three sustainability dimensions, including the three dimensions as intersecting circles or as sides of a triangle. Kelly provides a compilation of such diagrammatic representations of sustainability (*3*).

Strong and Weak Sustainability

Also relevant in this discussion is the difference between what are termed strong and weak approaches to sustainability (*11*). A weak approach to sustainability is one in which trade-offs among various facets of sustainable development (i.e., the dimensions) are considered acceptable. In other words, the weak approach views man-made capital and natural resources as interchangeable, without consideration of the finite qualities of the ecosystem. On the other hand, the strong approach views natural capital as the limiting factor. While a strong approach to sustainability is most desirable, often trade-offs are necessary. Gudmundsson also provides a comprehensive discussion of issues relating to weak and strong sustainability and recommends a nuanced approach to the issue of trade-offs, for example, by identifying certain critical environmental resources that cannot be depleted, as opposed to some that may be substituted or renewed (*1*).

SUMMARY OF KEY SUSTAINABILITY ISSUES

Because of the wide scope of sustainability, there are many issues involved in defining and measuring it. The terminology cuts across a number of scientific disciplines rather than forming a universal language. Appendix B provides a glossary that explains the most important issues and concepts. This section summarizes the most essential observations from this much wider debate.

The research team posits that sustainability denotes a state to be aspired to, even if it cannot necessarily be reached. Sustainable development, on the other hand, can be viewed as a process by which sustainability could be attained. It is also acknowledged that the term "sustainable development" can sometimes be more limiting than "sustainability," in that it focuses more on human needs (i.e., the development aspect). In this research the two terms are used interchangeably, with the understanding that while sustainability reflects a broader scope and is a convenient term to use, true sustainability is more of an idealized state that can potentially be reached through sustainable development.

The following points summarize the research team's understanding of sustainability, which forms the basis for applying sustainability in the transportation context:

- While there is a distinction between the terms "sustainability" and "sustainable development," the terms are used interchangeably with the understanding that true sustainability is not necessarily something achievable, and that when sustainability is referred to, it can be taken to represent a direction and not an end state.
- The definition of sustainability/sustainable development will be contested, and it is not the purpose of this study to resolve that. A preferred approach is to note the key components of sustainability and develop objectives and strategies to operationalize them within the relevant system boundaries.
- Sustainability is typically considered a combination of economic, social, and environmental progress, usually termed "sustainability dimensions." The issues of future needs (i.e., intergenerational equity) are also relevant.
- Growth in well-being rather than pure economic growth is desirable, and this brings in the issue of having a strong versus weak approach to sustainability. There is a need to understand the implications and trade-offs if all aspects of sustainability are treated as fully tradable concerns from the economic paradigm (i.e., when a weak approach is adopted).

Hence, the core principles of sustainable development—which include meeting human needs and improving community health and vitality; living within the earth's ecological carrying capacity and maintaining/enhancing natural capital; and protecting future generations—have been used as a starting point in addressing sustainability and its relation to transportation in this research.

Sustainability in the Transportation Sector

Transportation, as a major human activity, is an important consideration for sustainability. When addressing sustainability in relation to transportation, there are two divergent approaches noted among literature and practices—one that is centered on transportation (i.e., a transportation-centric view) and another that looks at transportation in support of a broader agenda for sustainability (i.e., a holistic view) (*2*).

While the term "sustainable transportation" is often used in the context of transportation and sustainability, it can sometimes narrow the scope of the problem being addressed. To quote Greene, "Sustainability pertains to the responsibility of an entire generation of society to future generations; whether it can meaningfully be applied to a single area of human activity such as transportation has been a subject of debate. That is, sustainability must be satisfied by the integral activities of a society and so, in this sense, it is not possible to judge whether one sector of society is sustainable on its own" (*12*).

The core principles of sustainable development have been incorporated to varying degrees in several conceptualizations of sustainable transportation (*4, 13, 14*). In general, sustainable transportation is articulated using the sustainability dimensions (also termed the three E's—environment, economy, and equity/society/employment) (*15, 16, 17, 18*) and is treated as "an expression of sustainable development in the transportation sector" (*19*). A limitation of this conceptualization is that it has the potential to perpetuate the status quo by focusing only on change ***within*** the transportation sector to the exclusion of change ***across*** sectors. It can be argued that the sectoral focus implied by sustainable transportation may limit opportunities for radical technological and societal transformations across several systems/sectors at once (*2*). Thus, an important question is whether it is more beneficial to develop transportation policies from a ***sustainable development*** (i.e., holistic) rather than a ***sustainable transportation*** (i.e., transportation-centered) perspective.

Table 1 summarizes the differences between a holistic and transportation-centric approach to sustainability. In practice, neither the transportation-centered nor the holistic approach will be easy to implement. However, the need for a strong and long-term federal commitment to sustainable development makes the holistic approach significantly more challenging. This observation is perhaps one reason why the transportation-centered approach has monopolized the attention of sustainable transportation researchers and practitioners. The research team proposes that a transportation-centric viewpoint can be considered as a starting point to addressing sustainability among transportation agencies. However, there should be an underlying recognition of the need for a more holistic approach in viewing transportation from a sustainable development perspective.

Table 1. Advantages and Disadvantages of Adopting a Transportation-Centered or Holistic View of Sustainable Development.

	Sustainable Transportation (*Transportation-Centered View*)	**Viewing Transportation from the Perspective of Sustainable Development** (*Holistic View*)
Focus	• Single system/sector.	• Multiple systems/sectors.
Advantage	• Provides sector-specific objectives and principles that guide the development of transportation policies and programs. • Does not require a strong external commitment to sustainable development to enact sustainable transportation policies/programs at the regional/local level.	• Highlights the need to establish a national framework/policy to address sustainable development that can encourage sectors to coordinate/integrate their activities.
Disadvantage	• Does not explicitly connect impacts from the transportation sector with those from other sectors. Thus, transportation tends to be considered in a vacuum.	• Does not provide detailed sector-specific objectives and principles to guide the development of transportation policies and programs. • Requires a strong and long-term external commitment to sustainable development that may not be forthcoming in the current political climate.

Examples of Sustainable Transportation Definitions and Implementation into Practice

As mentioned previously, there is a significant amount of research on sustainability focused on transportation, including attempts by transportation agencies to define sustainable transportation. For example, a commonly cited definition of sustainable transportation was adopted by the European Conference of Ministers of Transport (ECMT) (*20*). The ECMT's definition is based upon an earlier definition created by the Centre for Sustainable Transport in Canada in 1997 (*16*). These definitions are in the form of principles that emphasize basic access needs, human and ecosystem health, equity, affordability, system efficiency, and limiting of emissions and waste.

Banister described a sustainable mobility paradigm involving four primary elements (technology, demand management, integrated land use and transportation planning, and public awareness and acceptance) (*21*). This concept of sustainable mobility was thought of as a broader and more encompassing concept than sustainable transportation, understood to refer to not only physical movement (i.e., transportation) but also the spatial, economic, and social contexts (*22*).

Another definition of sustainable transportation is that it balances "the need to travel with the need to improve quality of life" (*23*). In the U.S. context, the Committee for the Conference on Introducing Sustainability into Surface Transportation Planning defined a sustainable

transportation system as “one in which (a) current social and economic transportation needs are met in an environmentally conscious manner and (b) the ability of future generations to meet their own needs is not compromised” (*24*).

Studies of transportation agencies in the United States indicate that while sustainability is not explicitly mentioned in the mission and vision statements of most agencies, a majority of them touch upon sustainability concerns by addressing issues such as the environment, future needs, and social equity (*25*, *26*). A review of the literature indicates that there are certain commonalities among various sustainable transportation initiatives and definitions; these broadly include concerns about environmental impacts and emphasis on safety, affordability, and accessibility of transportation services. In terms of goals for sustainable transportation, past research has indicated that potential objectives and goals of sustainable transportation range from maximizing accessibility, safety, and pedestrian/bike usage, to minimizing ecosystem impact and costs (*27*). More recently, the American Association of State Highway and Transportation Officials (AASHTO) listed a set of 17 goals for sustainable transportation (*28*). AASHTO also hosted a peer exchange on sustainability, which identified a set of seven focus areas for sustainable transportation, including social well-being and responsibility; material flows and management; energy, fuel, and climate; habitat, ecosystems, and storm water; economic efficiency; health and safety; and land use (*29*). The focus areas and goals of sustainable transportation found in the literature generally entail combinations of overall principles (such as equity and well-being); more specific concerns with goals for issues like affordability, health, ecosystem protection, and climate; and proposed strategies or measures in areas like land-use planning, bike use, alternative fuels, recycling, and material flow management.

PERFORMANCE MEASUREMENT FOR SUSTAINABILITY AND TRANSPORTATION

Overview of Performance Measurement

Performance measures (or indicators) are measurable criteria that can be used to evaluate progress toward achieving goals and can be applied in many ways. The generally applicable performance measurement process can be described as having the following steps (*30*):

1. Determine objectives.
2. Set targets.
3. Measure performance.
4. Monitor performance against targets.
5. Evaluate and review the process.

The outcome of this process can lead into decision making or actions taken to improve performance.

While starting out as a tool to improve efficiencies and performance in the private sector, performance measurement has become increasingly common among public-sector agencies as well. Transportation agencies are public entities with a range of stakeholders and are facing increasing scrutiny from the general public. Thus, these agencies can benefit from the proper application of performance measurement and management.

Behn identified eight main purposes for using performance measurement in the public sector: to evaluate, to control, to budget, to motivate, to promote, to celebrate, to learn, and to improve

(*31*). While evaluation was identified as the most common use of performance measurement, it was stressed that all these purposes overlap, and all tie in to the final purpose of overall improvement. While data availability/use of the right data is a very important consideration, it needs to be combined with a clear idea of appropriate data for a particular use.

REQUIREMENTS FOR ROBUST PERFORMANCE MEASUREMENT SYSTEMS

Research and guidance on implementing performance measurement emphasize the importance of creating tailored measures that fit the culture and constraints within individual agencies. Even if organizations have similar areas of focus, they may apply measures differently or use different data collection methods, benchmarks, etc. However, there are certain commonalities identified in research as to what constitutes good or robust performance measurement. Zietsman identified a set of 15 characteristics of good performance measures, including being measurable, relevant, sensitive to change, indicative of trends, etc. (*27*). Similarly, Marsden et al. assembled a set of attributes for good performance indicators identified from a variety of sources (*30*). Good performance indicators:

- Are relevant to the organization/strategy.
- Are clearly defined/easy to understand/transparent.
- Are based on available data/measurable.
- Are controllable/attributable.
- Are limited in number.
- Are timely.
- Avoid perverse incentives/are non-corrupting/are not corruptible.
- Are statistically/scientifically valid.
- Are comparable/consistent over time.
- Are responsive.
- Allow innovation.
- Are capable of aggregation.

A comprehensive analysis of criteria for selection of performance measures was developed in the report on environmental sustainability indicators for transportation, edited by Jourmad and Gudmundsson (*32*). The authors defined 10 criteria that fall into the following groups:

- Representation of reality (criteria such as validity and reliability).
- Monitoring and operation (criteria such as measurability, data availability, and ethical concerns).
- Management and policy (criteria such as transparency, target relevance, and action ability).

USE OF PERFORMANCE MEASUREMENT AND MANAGEMENT BY U.S. TRANSPORTATION AGENCIES

Performance measures are increasingly used by state DOTs and other transportation agencies, and are a key mechanism employed to monitor progress toward a set of goals. Guidelines for the development and tracking of transportation performance measures and the integration of these measures into transportation agency decision making have become well established in recent years, and include a number of projects conducted under NCHRP (*33, 34, 35, 36, 37*).

Legislative mandates sometimes drive the development of performance measures. In other instances, performance measurement/management is aimed at improving agency practices and accountability to external stakeholders. A 2003 NCHRP study identified key strategic areas of importance that many state DOTs already measure or seek to measure at a strategic level (*38*). These include:

- Mobility and congestion.
- Accessibility.
- Safety.
- Quality of life.
- Environment.
- Economic development.
- System preservation.
- Project delivery.
- Traffic operations.
- Maintenance.
- Human resources.

When assessing the extent of use of performance measures in these areas, it is generally noted that performance measurement is more widely implemented in operations-focused areas (such as congestion/mobility) and for organizational performance (for example, project delivery/human resources).

Applying Performance Measurement for Sustainability

A question that arises is how sustainability performance measures/indicators differ from other performance measures traditionally used by transportation agencies. Litman and Burwell distinguish between what are termed conventional transport indicators and those that can be termed sustainability indicators (*9*). For example, there is a need to shift from using automobile-centric (and operations-focused) performance measures to assessing indicators that are more holistic, even if they are more difficult to measure. Similarly, Zietsman summarized the paradigm shift that occurred over time—moving from measuring mobility to accessibility, and from outputs to outcomes (*27*). Thus, while the use of sustainability performance measures and indicators requires the same adherence to sound performance measurement principles (i.e., use of relevant measures, based on available data, responsive to trends, etc.), sustainability performance measures and indicators also need to take into account a broader sense of what sustainability is. This approach is typified by Marsden et al., who screened sustainability indicators by considering their relevance to transportation and to sustainability outcomes, and whether the indicators were of acceptable quality in terms of desirable characteristics for a performance measure (*30*).

There exists substantial literature on sustainability indicators, both general indicator sets and those specifically geared toward the transportation sector. Hall (*2*), Litman (*39*), and Jeon and Amekudzi (*25*) are examples of resources that provide comprehensive summaries of a range of sustainability indicator sets from many U.S. and international organizations.

Another application of sustainability performance measures in the transportation sector involves the use of rating systems for sustainability. The following lists selected transportation sustainability rating systems that were reviewed as part of this research:

- Federal Highway Administration's (FHWA's) Sustainable Highways (*40*).
- Sustainable Transportation Access Rating System (STARS) (*41*).
- Greenroads™ (*42*).
- GreenLITES (*43*).
- Illinois Livable and Sustainable Transportation System and Guide (I-LAST™) (*44*).
- Green Guide for Roads (*45*).
- BE2ST-in-Highways™ (*46*).
- GreenPave (*47*).

Table 2 summarizes the main aspects of these systems. These are also described in further detail in the guidebook. Appendix A lists the websites of these rating systems.

Table 2. Summary of Selected Transportation Sustainability Rating Systems.

System Name	System Owner	Launch Date	Type of Rating System
FHWA Sustainable Highways	FHWA	October 2010	Self-evaluation
STARS	The North American Sustainable Transportation Council	Expected mid-2012	Third-party certification
Greenroads™	Greenroads Foundation	January 2010	Third-party certification
GreenLITES	New York State Department of Transportation (NYSDOT)	2008	State DOT–administered self-evaluation system
I-LAST™	Illinois Department of Transportation (IDOT)	2010	Self-evaluation
Green Guide for Roads	Transportation Association of Canada	Expected September 2011	Self-evaluation
BE2ST-in-Highways™	University of Wisconsin	2010	Self-evaluation
GreenPave	Ministry of Transportation of Ontario	2010	Self-evaluation

COMPREHENSIVE SUSTAINABILITY EVALUATION THROUGH PERFORMANCE MEASURES AND FRAMEWORKS

A framework can be viewed as a formalized system of goals, objectives, and performance measures applied for sustainability. Defining an appropriate framework can help resolve or clarify the issues related to developing an approach to comprehensively evaluating sustainability. Pei et al. discuss the validity of various performance measurement frameworks, including those

traditionally used in sustainability assessments (such as the triple bottom line) and those usually used in other fields (such as balanced scorecards, performance prism, etc.) (*48*). The authors also discuss the requirements of robust sustainability frameworks from a transportation perspective.

While there are many examples of sustainability indicators available in literature, as well as guidance on indicator selection and framework development, there are very few documented examples that move through all phases of the sustainability framework application process, including defining sustainability and applying performance measures. A notable resource promoting this approach is the Performance Measurement Framework for Highway Capacity Decision Making, or the Collaborative Decision Making Framework, developed under the Strategic Highway Research Program (*49*). Though not explicitly linked to sustainability, it provides guidance to define the appropriate use and formulation of performance measures across the stages of the planning and project development process.

Context for Applying Sustainability in U.S. Transportation Agencies

Transportation sustainability concerns often extend beyond the organizational boundaries of national, state, and local transportation agencies. Additionally, within an agency, sustainability cuts across many traditional organizational stovepipes, and covers planning, design, and implementation of projects and infrastructure, as well as day-to-day operations and maintenance. Progress on transportation sustainability therefore depends on the ability of agencies to acknowledge the overlaps that sustainability exposes among their organizational boundaries and their willingness to collaborate across traditional organizational lines. Additionally, the presence of legislative mandates or an authorizing environment that enables the implementation of sustainability is also important. This was discussed by Hall, who identified both the lack of legislative support and the structure of U.S. transportation agencies as barriers to effectively addressing sustainability considerations (*2*).

Provision of transportation infrastructure in the United States is the shared responsibility of agencies at three scales of governance including national, state, and regional/local levels:

- National level:
  - Congress and the executive branch.
  - U.S. Department of Transportation (USDOT).
  - FHWA Federal Transit Administration.
- State level:
  - State DOTs.
  - Independent state toll authorities.
- Regional and local level:
  - Metropolitan planning organizations.
  - Local public works and transportation departments.
  - Public transit agencies.
  - Local-level toll authorities.

However, transportation sustainability concerns flow across traditional organizational boundaries, and sustainability performance measures are needed that can both support the work of individual agencies and provide insight on progress at a broader scale.

Within individual transportation agencies, sustainability is influenced by many traditional organizational stovepipes in the project development process. For example, protection of watersheds depends—in equal measure—on choices made by the siloed organizational units of a transportation agency that are responsible for which projects get built, how they are designed and constructed, and how they will be maintained over their lifespan. Following is a brief overview of the generic processes that characterize project development and infrastructure management, which include long-range planning, programming, National Environmental Policy Act (NEPA) review, project design, construction, maintenance, and operations.

Long-Range Transportation Planning

The long-range planning process provides the means by which state DOTs and metropolitan planning organizations (MPOs) translate complex national, state, and local transportation interests and anticipated funding availability into a vision for state or regional transportation investment. States and regions develop their long-range transportation plans (LRTPs) through a range of approaches, and plans take on many different forms from broad policy statements to specific preferred investment strategies. An LRTP will often help quantify long-term needs, revenues, and funding gaps; identify and define investment strategies; and/or establish a framework, priorities, or other guidance to drive shorter-term investment decisions. The LRTP can also reflect the state and local sustainability objectives, policies, and programs.

While state DOTs and MPOs have significant leeway in how they develop and use their LRTPs, their planning processes must comply with federal and state planning laws, regulations, and guidance. These requirements include the basic federal requirement that states self-certify their long-range transportation planning process in conjunction with the submittal of a statewide transportation improvement plan (STIP) at least once every four years. States also develop plans around planning factors that have evolved over time and dictate the various considerations that must be incorporated into state planning processes. Long-range planning is a point at which expectations for sustainability performance can be discussed—particularly in terms of desired sustainability outcomes—and broad performance goals can be established that drive subsequent investment patterns.

However, there may also be state and local policies that extend beyond federal policies that may affect both the LRTPs and the planning process. Some of these policies may carry forward state and local sustainability objectives. For example, a few states have embarked on growth management programs aimed at keeping their states sustainable. Local governments regularly practice growth management. Concurrency is one approach to seeking long-term sustainability. Environmental, energy, and financial programs are different approaches. Some local or regional governments have looked at very long-range horizons (30 years to build out) in an attempt to forecast ultimate needs under a set of assumptions. All of these are examples of how long-range planning can incorporate sustainability considerations.

Short-Range Transportation Programming

State and local transportation departments use capital programming to match up priority project-level transportation needs with funds to fulfill them. The short-range capital program is a generic term used to describe an agency's list of high-priority transportation projects with well-

developed scopes and precise budgets to be built in a defined timeframe, and the process used by a state to arrive at the list and decide how money for transportation will be spent among competing project needs. An effective capital program should put the combined impact of many short-term, project-level spending decisions on track toward making progress in achieving long-term transportation goals that support national, state, and local interests. Development of a state or local capital program is usually a collaborative effort among the state DOT and its local and federal partners. Transportation programming is a point at which broad expectations about sustainability established in long-range planning can be translated into explicit targets associated with implementation of a specific set of projects.

When it comes to selecting and prioritizing projects for implementation, sustainability considerations can play a major role. These processes often use several criteria to compare the benefits that would result from candidate projects. Sustainability objectives are often used as a basis for the performance measures used in selection or prioritization.

Project-Level Planning

Once a transportation project is identified in a capital program, project delivery begins with planning, which takes place before environmental documents are prepared, and which varies among projects, states, and even local jurisdictions. In general, planning efforts are most extensive for major projects with potential for significant sustainability gains or environmental impacts. For example, an urban project that has as an objective to foster redevelopment or economic development may require the collaboration of several agencies and a multi-faceted project planning effort.

Minor projects, such as guardrail replacement, acquisition of new buses, or roadway resurfacing, may involve little or no planning activity. The planning phase helps agencies identify project needs, community concerns, and potential solutions. In many states, early consideration of environmental issues before an environmental document is prepared is an increasingly common part of project planning. Project-level sustainability performance measures may be used to inform project-level planning decisions.

Project-Level Environmental Review

Transportation infrastructure projects that receive federal support must follow an elaborate environmental review process designed to ensure that the impacts of agency actions on the environment are considered prior to project development. Federal environmental review procedures are guided by NEPA, which also functions as an umbrella process for assuring compliance with numerous other media-specific environmental laws and regulations that include permitting and consultation activities involving a variety of federal agencies. Some states have their own, more stringent environmental review procedures that exceed NEPA in certain aspects.

Frequent federal partners in the NEPA process include the U.S. Army Corps of Engineers (COE), the U.S. Fish and Wildlife Service (FWS), the Advisory Council on Historic Preservation (ACHP), the U.S. Environmental Protection Agency (EPA), and others. Most commonly, state DOTs lead the environmental process, but it may be carried out by a transit agency or a large local transportation department. NEPA establishes three classes of environmental review actions

for transportation projects, based on the magnitude of their anticipated environmental impacts, including an environmental impact statement (EIS) for major projects where a significant environmental impact is anticipated, such as construction of a new segment of controlled-access freeway. As in planning, project-level sustainability performance measures may be used to inform project-level environmental decisions. Since the project-level environmental review process is comprehensive, it encompasses most sustainability characteristics. A project that has minimal adverse environmental impacts usually has positive sustainability aspects. Positive progress on sustainability objectives usually contribute to a positive environmental result.

Design, Land Acquisition, and Permitting

Once the environmental process is complete and a basic horizontal and vertical alignment for the project is agreed upon, detailed engineering plans can be prepared. Most design work is unrelated to environmental mitigation. Design work may include environmental compensation or enhancement features, such as storm water control facilities, wetland mitigation, or noise walls. Permits from natural resources agencies, such as the U.S. Army Corps of Engineers, may also be required at this phase during project delivery and require time to prepare and approve. Permits may be required for wetland restoration, storm water runoff control, conservation of historic resources, or special construction management techniques.

Sustainability may also find its way into design and right-of-way determination related to such components as aesthetics, compatibility, multimodal accommodations, construction requirements, and materials and equipment selection, to name a few. These may also affect or become a requirement for permitting.

Design, land acquisition, and permitting represent a point at which predictions that occur in planning and environmental review can be verified on the ground and translated into outcome measures of sustainability.

Construction, Maintenance, and Operations

During construction, DOTs use contractors to build projects, and DOTs typically retain an overall project management and oversight role. There can be major sustainability considerations in construction, maintenance, and operations. Construction and staging footprints can affect the amount of land impacted by construction and the resulting degree of disruption and duration of construction, and can have an economic impact on the project area and beyond, as can construction materials and methods. Durability can vary as a result of a combination of materials and methods, and may affect the overall cost-effectiveness of the transportation investment. Many projects require erosion-control practices and storm water management that can reasonably be described as environmental costs. Decisions are made on many reconstruction projects to work at night or on weekends, to reclaim or recycle materials at existing facilities, and to preserve portions of a facility that can continue to serve satisfactorily for the project life. Extra-heavy components may be added to extend project life and reduce and defer maintenance requirements and costs.

Once a project is built, it is maintained and operated by the state or local agency. Many of the considerations described above also apply to maintenance. Disruption of service, regardless of

mode, can be a major sustainability consideration. DOTs use pavement and other management systems to track conditions and program maintenance on a strategic basis. Sustainability also influences selection of materials and methods and frequency of maintenance.

Operations affect the ultimate performance of the transportation facilities and services. DOTs at all levels utilize many tools to deliver efficient and safe operations. These range from basic tools like traffic signals, stop signs, and speed limits to more sophisticated tools like intelligent transportation systems. Performance measures, in the forms of traffic management systems or analytical performance assessments, are used by most transportation agencies to assess how well the systems are working and where improvements are needed. DOTs regularly try to upgrade operations to improve operational efficiency and safety—basic sustainability characteristics.

Legislative Mandates and Sustainability

The concept of sustainability presents a legislative and organizational challenge. Its broad environmental, social, and economic reach cuts across organizational and disciplinary lines that exist within the federal, state, and local governments. These divisions of expertise also exist in the private sector, which responds to the legislative frameworks created by government. Thus, the authorizing environment in which progress toward sustainable development is to be achieved is complex. The authorizing environments of state DOTs and other transportation agencies are driven by their mission statements, strategic goals, and other mandates. These may or may not include a focus on sustainability. For agencies to legitimately address concerns related to sustainability, their authorizing environment should enable them to do so.

In the United States, there is currently no federal regulation that explicitly focuses on sustainability. However, the social and environmental regulations that do exist, such as NEPA, the Americans with Disabilities Act (ADA), and the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), provide a patchwork framework for state DOTs and other transportation agencies to address components or elements of sustainability. Indeed, SAFETEA-LU and its two predecessors (the Intermodal Surface Transportation Efficiency Act [ISTEA] and the Transportation Equity Act for the 21st Century [TEA-21]) called for transportation agencies to promote economic development while protecting the environment and sustaining the quality of life. While there is currently no regulation on sustainable development, important elements of the concept are expressed in existing environmental, social, and sector-specific regulations. In this context, transportation agencies are already operating under a nonintegrated form of sustainability agenda, whether this is explicitly recognized or not.

The policy vacuum that currently exists with no federal legislation on sustainable development or sustainable transportation has provided states with an opportunity to take the lead in creating an authorizing environment conducive to sustainability. Many states and state DOTs have created authorizing environments to pursue sustainability goals. While these legislative frameworks establish the motivation for change, it is important that state DOTs and other transportation agencies invest time in understanding how sustainable development manifests in their particular case; that is, each region is likely to face a different portfolio of environmental, social, and economic challenges that will shape the agency response to these challenges.

SUMMARY REMARKS ON THE CONTEXT FOR APPLYING SUSTAINABILITY

Progress on transportation sustainability depends on the ability of transportation agencies to acknowledge the overlaps that sustainability exposes among their organizational boundaries and their willingness to collaborate across traditional organizational lines—both inside and out. While the focus of the project is on state DOTs and MPOs, the needs of other transportation agencies are also a consideration, as is an understanding of how agencies interact with each other (i.e., organizational coordination) and with other elements outside the transportation sphere.

IDENTIFICATION OF BEST PRACTICES AND CASE STUDIES

As part of the preliminary project tasks, the research team conducted detailed case studies to identify best practices for applying sustainability among transportation agencies in the United States and worldwide. In order to select agencies for the case studies, an initial screening was conducted to identify candidate agencies. The initial screening included state DOTs, MPOs, transit agencies, municipal governments, and international transportation agencies. The screening exercise documented the current practices of this selected, representative cross section of transportation agencies with respect to the identification, adoption, and use of sustainability performance measures. In some instances the case study agencies had not adopted sustainability performance measures, but were undertaking related activities or working toward the identification and adoption of such measures. These agencies were included if they had valuable lessons to share because there is value in documenting agencies that are at different stages of development. Based on the findings from the screening exercise, a set of 14 agencies were selected as case studies:

- State departments of transportation:
  - California Department of Transportation.
  - Colorado Department of Transportation.
  - Florida Department of Transportation.
  - Minnesota Department of Transportation.
  - New York State Department of Transportation.
  - Oregon Department of Transportation.
  - Washington State Department of Transportation.
- Metropolitan planning organizations:
  - Chicago Metropolitan Agency for Planning (CMAP).
  - Mid-Ohio Regional Planning Commission (MORPC).
  - Metropolitan Washington Council of Governments (MWCOG).
- Other agencies:
  - Hampton Roads Transit.
  - City of Alexandria, Virginia.
- International agencies:
  - Swedish Road Administration.
  - U.K. Highways Agency.

Appendix C contains the findings from the initial screening of transportation agencies. The case study interview guide and questions are also included in the appendix. The main findings from the detailed case study interviews were summarized and studied to identify trends and conditions, common challenges, and specific lessons learned, as well as an idea of best practices

that can be applied to build and finalize the framework for this project. A summary of the individual case studies is provided in the project guidebook. Table 3 contains a tabular summary of the main findings from the case studies. The Notes/Highlights section provides some background and context on each agency's status or process as it incorporates sustainability and performance measurement into its practices.

Table 3. Summary of Sustainability Efforts at Selected U.S. and International Agencies.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
California Department of Transportation (Caltrans)	Ensuring that environmental, social, health, and economic considerations are factored into decisions about transportation activities.	• California Transportation Plan. • Regional Blueprints. • California Progress Report. • Strategic Growth Council. • Transportation System Information. • Office of Strategic Planning and Performance Measurement. • Smart Mobility Framework.	Caltrans is managing many programs that relate to aspects of sustainability and span regional and statewide levels. It is relatively well advanced in measuring these concepts. The agency is working to begin to implement projects that will bring to fruition those goals and objectives identified in the strategic planning and policy documents.
Colorado Department of Transportation (CDOT)	No official agency definition but following general concept of the Brundtland definition.	• Environmental Stewardship Guide. • Transportation Environmental Resource Council's (TERC's) sustainability subcommittee. • Greening Council—greening government initiative. • I-70 Corridor—sustainability applications.	CDOT is engaged with an interagency working group, TERC, which has established a sustainability subcommittee. The group is attempting to establish the principles of sustainability for all state agencies and, from there, determine how they should impact transportation policies and programs.
Florida Department of Transportation (FDOT)	As defined in the 2025 Florida Transportation Plan: "Meeting the needs of the present without compromising the ability to meet the needs of the future."	• Florida Transportation Plan. • Strategic Intermodal System. • Metropolitan Planning. • Regional Visioning. • Efficient Transportation Decision Making. • Executive Order 07-126.	FDOT has been on the forefront of tracking and measuring performance. However, the agency has not yet classified any current measures as sustainability measures. Throughout agency practices there are many activities that could fall under a sustainability umbrella.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
Minnesota Department of Transportation (MnDOT)	No official definition, although agency's vision refers to a "safe, efficient, and sustainable transportation system."	• State transportation plan. • Internal strategic planning.	MnDOT is a leader in performance-based planning. Many of the existing measures relate to sustainability, but the agency has not grouped them as such.
New York State Department of Transportation	A transportation system that supports a sustainable society is one that: • Allows individuals and societal transportation needs to be met in a manner consistent with human and ecosystem health with equity within and between generations. • Is safe, affordable, and accessible; operates efficiently; offers choice of transport mode; and supports a vibrant economy. • Protects, preserves, and enhances the environment by limiting transportation emissions and wastes; minimizes the consumption of resources; and enhances the existing environment as practicable.	• GreenLITES.	GreenLITES was designed as a certification program for new highway miles. However, NYSDOT realized that this program has limited impact, and a new program-level approach is underway.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
Oregon Department of Transportation (ODOT)	Using, developing, and protecting resources in a manner that enables people to meet current needs while providing for future generations to meet their needs, from the joint perspective of environment, economic, and community objectives.	• Sustainability Plan and Implementation. • ODOT Sustainability Council. • Oregon Transportation Plan Goal. • Environmental Management System. • Office of Innovative Partnerships and Alternative Funding.	ODOT is institutionalizing the concept of sustainability through the development of an integrated strategic sustainability program and an implemented sustainability plan. Through these actions, sustainability will become a guiding principle for the agency. ODOT does not view sustainability as an impact but instead an opportunity to improve efficiency. The sustainability plan identifies the need for measuring the agency's progress on implementation and identifies measures, but much of the data required for tracking is not currently being collected.
Washington State Department of Transportation (WSDOT)	In the process of defining sustainability.	• All programs relate to sustainability, but three offices lead the effort: Public Transportation, Strategic Planning and Programming, and Environmental and Engineering Programs.	WSDOT has a significant history of tracking performance measures in its Grey Notebook. However, it is only currently developing sustainability performance measures and determining ways to measure them and implement them into decision making.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
Chicago Metropolitan Agency for Planning	Can be used in one of three ways: • Sustainability requires that any public policy or investment meet certain environmental, economic, and social equity goals. • Sustainability meets the needs of the present without compromising the needs of the future. • Sustainability regards the total wealth of society as capital that should be preserved or increased, including natural capital, human capital, and man-made capital, in addition to financial wealth.	• CMAP believes that sustainability cuts across all program areas. Go To 2040 is the specific program area highlighted for this case study.	CMAP defines all 250 performance measures as sustainability measures. Evaluation of the sustainability of planned projects and ongoing monitoring of the region's sustainability are now central to CMAP's way of doing business.
Mid-Ohio Regional Planning Commission	Meeting the needs of the present without compromising the ability of future generations to meet their own needs.	• The Green Pact Program, run by the Center of Energy and Environment. • Complete Streets. • Public Policy Agenda. • State of the Region Reports. • Long-Range Plan.	MORPC reports that it has been considering sustainability for decades and calling it "good planning." In recent years, MORPC has promoted sustainability performance indicators through its annual State of the Region reports.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
Metropolitan Washington Council of Governments	No agency-wide definition, but it is one of four guiding principles in recent policy study: sustainability—healthy air, water, and land; abundant renewable energy sources; and a smaller carbon footprint.	• Region Forward Report.	Region Forward is a policy-level visioning study that identifies the region's shared goals for land use, transportation, environment, climate and energy, economy, housing, education, health, and public safety. The concepts have yet to be integrated into actual planning and policy decisions, but are meant to provide guidance and encourage new ways of thinking about those processes.
Hampton Roads Transit (HRT)	Sustainability to HRT is about making Hampton Roads a more livable community today and into the future; by providing accessible, efficient, and environmentally friendly public transportation services; and operating its vehicles and facilities according to policies and procedures that promote pollution prevention, climate protection, and energy and resource conservation.	• Environmental Management System. • American Public Transportation Association's (APTA's) Sustainability Commitment. • International Association of Public Transport Charter on Sustainable Development. • Hybrid Vehicles and Clean Fuel. • Energy Reduction Lighting Program.	The Environmental Management System (EMS) has been developed to guide all agency practices toward sustainability. The EMS is new, and HRT has set modest goals and plans to build upon them each year as the initial goals are met. APTA's Sustainability Commitment is helping to guide HRT's programs.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
City of Alexandria, Virginia	Sustainability is progress that meets the needs of the present without compromising the ability of future generations to meet their needs. A sustainable community is an environmentally, economically, and socially healthy place where people can live, work, and play for decades to come.	• Environmental Action Plan 2030.	Alexandria is working to use the Environmental Action Plan to incorporate the concepts of sustainability into its Master Plan and Area Plans.
Swedish Road Administration	No official agency definition; one of six goals is a sustainable environment: a good environment, where the design and performance of the road transport contributes to achieving environmental quality targets.	• Strategic Plan. • Annual Score Cards. • Goals and Metrics Database. • Annual Report. • Annual Sectoral Report. • Annual Action Plan.	Sustainability has been part of the transport policy in Sweden since the late 1980s and is incorporated into all aspects of planning and programming.

Agency	Definition of Sustainability	Programs Highlighted	Notes/Highlights
Highways Agency (England, United Kingdom)	The agency's actions must support five overarching goals of the United Kingdom–wide strategy: • Living within environmental limits. • Ensuring a strong, healthy, and just society. • Achieving a sustainable economy. • Promoting good governance. • Using sound science responsibly.	• Sustainable Development Action Plan (SDAP). • SDAP Progress Report. • Business monthly report card. • Corporate Social Responsibility Report.	Sustainable development has been considered in management goals since 2005 when the agency began corporate responsibility reporting. The agency has efforts that cut across all program areas related to sustainability and sees this focus as a "realignment, not a revolution."

Discussion of Case Study Findings

The findings from the case studies revealed that the reviewed agencies have adopted a range of working definitions of sustainability. Several agencies focus on the long-range effect of program decisions, including an assessment of the impact on future generations. While some agencies use some version of the triple bottom line to gauge sustainability (i.e., assessing outcomes by environmental, economic, and social criteria), others consider sustainability a primarily environmental metric. Finally, agencies vary in the scope and scale of consideration of sustainability, ranging from a focus on project-level assessments to more program-level or landscape-scale reviews.

The case study findings included observations made for domestic and international agencies, in terms of trends and conditions, challenges faced, and best practices. These are presented briefly below. The guidebook contains more detailed discussion of the case study findings.

Trends and Conditions Observed

In terms of U.S. agencies, perspectives on sustainability are in flux, marked by a surge in support and new initiatives, as well as some skepticism. Overall, trends observed include increased public awareness and legislative mandates in some states. However, some agencies view sustainability as a new word for long-standing concepts of good planning and stewardship. From an international agency perspective, the sustainability state of the practice varies. In many cases, sustainability programs have been in existence longer than in the United States, and there are more instances where sustainability is used as an organizing principle for agencies, and internal agency acceptance of sustainability is found to be more widespread.

Challenges Faced by Transportation Agencies

As agencies work to incorporate sustainability principles, several themes have emerged about the challenges these agencies are facing. From a U.S. agency perspective, the challenges cited include the turning of goals into measureable actions, the trade-offs between aspects of sustainability, data, agency jurisdiction, and prioritization of issues. The challenges identified by international agencies in terms of sustainability include cost, data, and measurement issues, as well as concerns about the final impact of sustainability metrics on decision making.

Best Practices and Lessons Learned

The growing experience and success of transportation agencies in integrating sustainability into their work provides several lessons learned that can be useful guidance to other agencies. From a U.S. agency perspective, the following was identified as contributing to successful implementation of programs for sustainability, including sustainability performance measures:

- Viewing sustainability in the big picture, i.e., recognizing that sustainability is a comprehensive concept.
- Having the presence of a strong and committed leadership, and working with other agencies in the process.
- Committing to a long-term effort and setting appropriate goals and targets.

- Making sufficient resources available.
- Linking sustainability to funding.

In studying the experience of international agencies, some additional lessons learned include the following:

- The goal should be implementation of sustainability in an integrated manner, throughout the agency, with the recognition that it is an ongoing, long-term process.
- Defining performance measures and implementing them are the key to progress. Neutrality of the agency/entity compiling data promotes trust in the findings and recommendations made.

CONCLUDING REMARKS

This chapter discussed the literature review, study of general practice, and case study interviews conducted as part of this research. The next chapter presents the development of a generally applicable framework for sustainability based on the findings from this chapter. The following points encapsulate the approach to developing a generally applicable sustainability framework for transportation agencies based on the research team's consolidated findings and subsequent conclusions and recommendations:

- A distinction is made that sustainability denotes a state to be aspired to, even if it cannot necessarily be reached, while sustainable development can be viewed as a process by which sustainability is attained.
- Since the definition of sustainability/sustainable development will be contested, a preferred approach would be to note the key components of sustainability and develop objectives and strategies to operationalize them within the relevant system boundaries. The principles of sustainability put forward in the literature review section were used as a starting point.
- Sustainability is typically considered a combination of economic, social, and environmental progress, usually termed sustainability dimensions. The issues of future needs (i.e., intergenerational equity) and governance are also relevant. It is also important to acknowledge the interconnection between sustainability dimensions and to respect that while gains in all areas are desirable, there will be trade-offs over time that need to be carefully considered. This brings in the issue of having a strong versus weak approach to sustainability and understanding the implications of each approach. A weak approach is more flexible with regard to allowing trade-offs between dimensions and areas, but compared to the strong approach, it engages higher risks with regard to maintaining critical environmental resources and the opportunities for future generations to exploit them.
- While a holistic approach to sustainability is essential, it does not imply that the concept of sustainable transportation is rendered meaningless. Rather, it means that sustainability in transportation (or sustainable transportation) should be addressed keeping in mind that transportation is one part of a larger system.
- A specific emphasis should be given to the design of *integrated* and *coherent* policies and programs that seek to improve the social, environmental, and economic performance of the transportation sector without negatively affecting the performance of other sectors.

CHAPTER 3—DEVELOPMENT OF A SUSTAINABILITY FRAMEWORK

The application of the concept of sustainability by transportation agencies is often limited by agencies' understanding of what sustainability means and a lack of a clear method on how it can be integrated into their regular functions. This chapter presents a flexible framework that will equip transportation agencies with the tools required to understand what sustainability means, incorporate the principles of sustainability into their organizational culture, and lay the groundwork for the use of performance measures to implement sustainability by progressing toward sustainability goals and outcomes. A key feature of this framework is that it extends beyond the traditional sustainable transportation perspective and instead promotes the consideration of transportation from a holistic sustainable development perspective. The framework can be applied/adapted for use in a broad range of transportation agencies and at any level within such agencies. The framework defines broadly applicable transportation goals that can be broken down into a menu of objectives and performance measures to cover various transportation contexts. The framework is also designed to direct an agency's strategic planning toward the practical implementation of sustainability through performance measurement. The term "framework" as used here is in a broader context than in some examples of sustainability frameworks seen in literature. We choose to distinguish such examples as application frameworks, which can be viewed as tools, approaches, techniques, and methodologies to be used in conjunction with this proposed broad and generally applicable framework.

FRAMEWORK COMPONENTS

In identifying components to be included in the sustainability framework, the question to be answered is "*What does a transportation agency need to be equipped with in order to successfully address sustainability issues through performance measurement?"* Fundamentally, the use of performance measurement for sustainability involves understanding sustainability; developing appropriate goals, objectives, and performance measures; and applying the performance measures to agency activities. There are some overarching and auxiliary aspects that also need to be considered. Thus, the framework for comprehensive performance-measurement-based implementation of sustainability has components that can be classified as follows:

1. **Fundamental components**—These are elements that are required for the application of the framework in a step-by-step manner. These include:
   - An understanding of sustainability.
   - Development of transportation sustainability goals.
   - Development of objectives.
   - Implementation of transportation sustainability performance measures.
   - Feedback.
2. **Overarching components**—These are elements that need to be considered throughout the framework application process. These include the engagement of stakeholders, partners, and external agencies throughout the process.
3. **Auxiliary components**—These are related but optional components that can be used to supplement the framework application process, including:
   - Agency definition of sustainability.

- Organizational sustainability initiatives.
- Organizational transportation sustainability performance measures.

Figure 1 (in the executive summary) shows a simplified framework diagram. Figure 2 shows a more detailed diagram with the various framework components and interactions. The framework components are then described in detail.

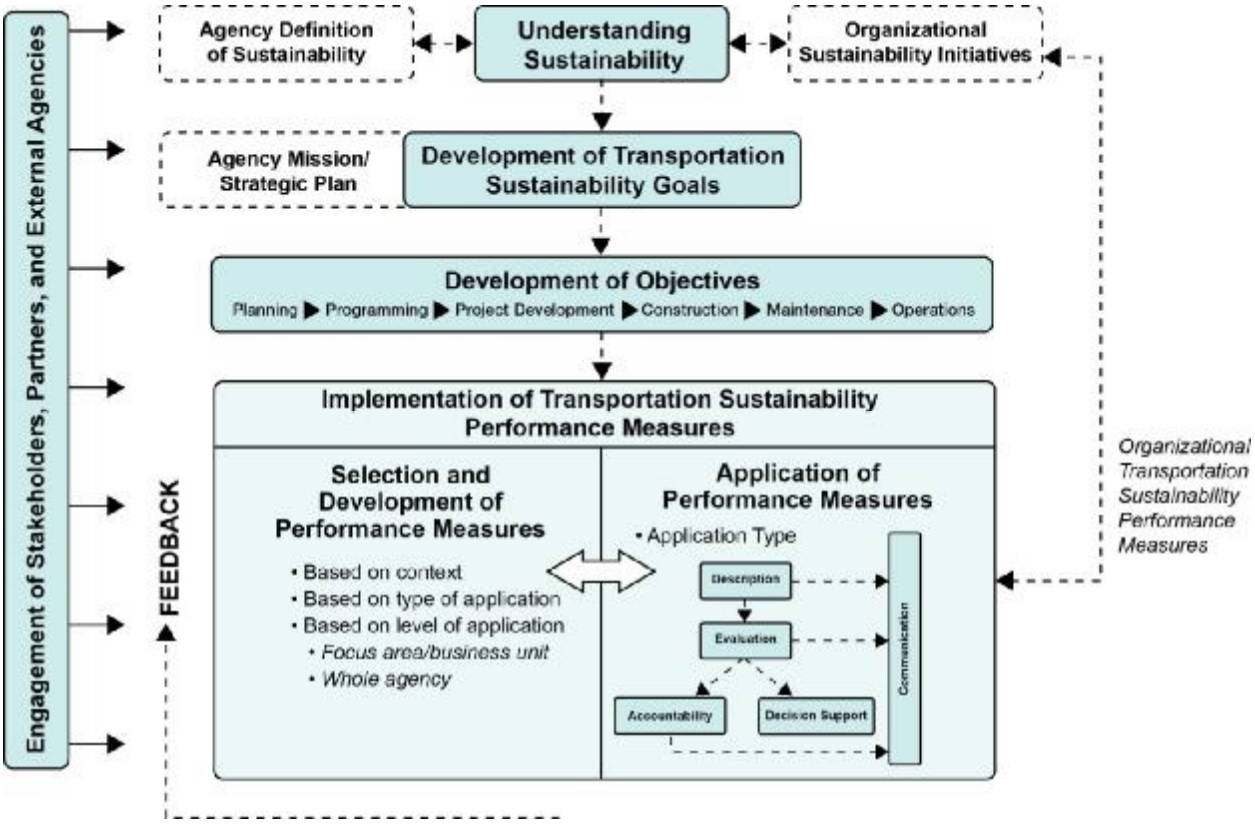

Figure 2. Detailed Framework and Component Interactions.

FUNDAMENTAL FRAMEWORK COMPONENTS

The fundamental framework components can be viewed as a sequence of steps that represent the entire process of understanding sustainability to applying sustainability performance measurement. While sequential, these framework steps are not to be viewed as a linear process that terminates, but rather as an iterative process with feedback being used to improve the different steps and the eventual application of sustainability performance measures. These steps are also informed and supported by various auxiliary and overarching components.

Understanding Sustainability

Understanding what sustainability means is the first step in being able to apply a framework for sustainability. This framework defines a set of general, inclusive principles of sustainability that are considered a non-negotiable baseline, which draws from the core principles identified in

Chapter 2. The purpose of these principles is to ensure that the transportation agency encourages and maintains progress toward sustainability. Transportation agencies should consider these principles and debate how they relate to a specific organization. The next steps in the framework, including the development of goals, objectives, and performance measures, help to clarify how the broad sustainability principles translate to the transportation sector and to the mission of a specific transportation agency. However, at the broad level of sustainability principles, it is important to understand the holistic nature of sustainability, including the interconnection between sustainability dimensions and the significance of inter-generational and intra-generational equity.

The basic principles of sustainability as defined in this research are that sustainability entails meeting human needs for the present and future, while:

- Preserving and restoring environmental and ecological systems.
- Fostering community health and vitality.
- Promoting economic development and prosperity.
- Ensuring equity between and among population groups and over generations.

These principles were assembled based on a review of foundational literature and documents on sustainability, sustainable development, and sustainability in transportation, including the Brundtland Commission Report (*50*), the Natural Step Approach (*51*), Natural Capital (*8*), the World Business Council for Sustainable Development (*52*), and the European Council of Ministers of Transport (*20*).

Examples of past transportation sustainability implementation efforts have often focused on transportation agencies defining sustainability for their own purposes. While defining sustainability is viewed as a valuable exercise, the definition of sustainability does not form the basis for the application of the framework, which is instead rooted in these principles. The definition of sustainability is therefore regarded as an auxiliary or supporting component in this framework.

To develop a better understanding of sustainability, transportation agencies should consider these principles and debate how they relate to a specific organization. The next steps in the framework, including the development of goals, objectives, and performance measures, help clarify how the broad sustainability principles translate to the transportation sector and to the mission of a specific transportation agency. However, at the broad level of sustainability principles, it is important to understand the significance of equity as a component of the principles, and to also understand the interconnection between the social, economic, and environmental dimensions.

Significance of Equity to the Principles of Sustainability

Equity within and across generations is an important aspect of the framework and is often neglected in discussions of sustainability because it is the most difficult to quantify and address. It is imperative that equity be treated as an integrated part of the framework to better address the distribution of economic and environmental benefits and community health and vitality improvements, which are represented in the other principles of sustainability.

Figure 3 shows a visual representation of how the principle of equity is viewed as reinforcing the environmental, economic, and social dimensions of sustainability, which are represented as a three-legged sustainability stool. Equity is not seen as a separate leg of the stool; instead it is seen as an overarching principle that plays a major part in each of the other principles.

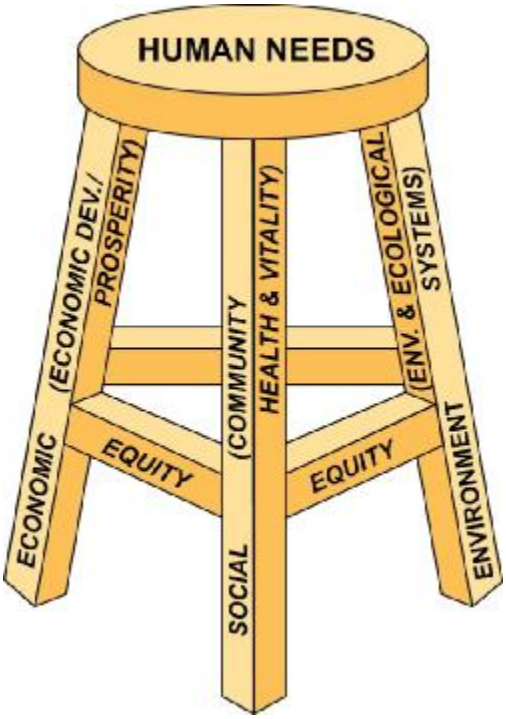

Figure 3. Principles of Sustainability and the Significance of Equity.

Addressing Social, Economic, and Environmental Issues for Sustainability

It is important to acknowledge the interconnection between social, economic, and environmental issues and to respect that while gains in all areas are desirable, there will be trade-offs over time in their achievement. A weak approach to sustainability is one in which trade-offs among various dimensions are considered acceptable, while a strong approach does not. The aim of the framework proposed here is to provide a comprehensive coverage of sustainability issues and to conduct and explain any prioritization in a transparent manner.

Development of Transportation Sustainability Goals

The aim of developing goals is to operationalize the general sustainability principles within the transportation sector. The practical implementation of sustainability for a transportation agency must consider constraints within which these agencies operate. While it is recognized that a more holistic approach that promotes integration among sectors and inter-agency cooperation is desirable, it is proposed that a transportation-centric approach with sector-specific goals be used as a start.

Recommended Goals for Sustainability in the Transportation Sector

The development of a set of goals is an important part of the process of thinking through what the sustainability principles mean for transportation agencies. A set of 11 goals are proposed as part of this framework and can be used as a starting point for agencies to either modify/refine these goals or use them directly in the framework application process. The goals were identified as key for transportation agencies to address the principles of sustainability and to promote sustainability in their activities. The goals were developed based on issues identified from literature review findings and raised by practitioners and researchers during case study interviews. These goals also provide transportation agencies with the means to work with other agencies (transportation and non-transportation related) since they are broad and encompass concerns within and outside of the transportation sector. Organizations can leverage each other's work when it comes to these goals through joint projects, shared expertise, shared resources, and cost savings obtained by matching funds and shared efforts such as through public involvement. The recommended goals for sustainability in the transportation sector are as follows:

1. **Safety**—Provide a safe transportation system for users and the general public.
2. **Basic accessibility**—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.
3. **Equity/equal mobility**—Provide options that allow affordable and equitable transportation opportunities for all sections of society.
4. **System efficiency**—Ensure the transportation system's functionality and efficiency are maintained and enhanced.
5. **Security**—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.
6. **Prosperity**—Ensure the transportation system's development and operation support economic development and prosperity.
7. **Economic viability**—Ensure the economic feasibility of transportation investments over time.
8. **Ecosystems**—Protect and enhance environmental and ecological systems while developing and operating transportation systems.
9. **Waste generation**—Reduce waste generated by transportation-related activities.
10. **Resource consumption**—Reduce the use of non-renewable resources and promote the use of renewable replacements.
11. **Emissions and air quality**—Reduce transportation-related emissions of air pollutants and greenhouse gases.

Developing and Adapting Transportation Sustainability Goals

Depending on the transportation agency and its function, the set of 11 recommended goals for sustainability in the transportation sector may or may not be used as a part of the framework. Some goals may not apply to some agencies or may have radically different importance within different local contexts. Specific local goals may need to be added, while others in the proposed goal set may not be included. While the recommended set of goals covers the principles of sustainability as reflected in the transportation sector, there are other categories of goals used in various initiatives by transportation agencies that could also be considered for inclusion. For example, Caltrans' Smart Mobility Framework includes goals such as public health and location

efficiency (*53*). The literature review and case studies described in Chapter 2 contain resources that may be useful in identifying additional goals.

Another important aspect is the agency's mission or strategic plan, which can be a valuable source for adapting sustainability goals to the specific context. Agencies should review these goals against strategic goals that they are being asked to support and deliver, and attempt to develop a comprehensive goal set that is connected to sustainability principles but also in line with the agency's overall mission. The 11 recommended goals can therefore be used as a beginning point and augmented using the agency's strategic planning goals. This is a crucial part of the process because it allows transportation agencies to deliberate about how goals of the organization relate to sustainability.

Agencies modifying/incorporating goals selectively should ensure development of a comprehensive goal set for their particular context and include goals that mirror the terminology already used (provide, ensure, protect and enhance, and reduce). Agencies should justify their selected goals and explain clearly the rationale for, and connection to, the principles of any new or additional goals by mapping them to the sustainability principles as described in the next section. When goals are omitted or realigned, the agency should attempt to maintain a goal set that is representative of all aspects of the sustainability principles, and provide explicit reasoning and justification for overrepresentation or the lack of representation of certain principles in the set of goals. As part of the goal review process, organizations should develop clear directions of change for their goals and include a transparent statement about how the equity impacts are being considered.

Since the final set of goals developed will be transportation focused, it is important that agencies still keep in mind the holistic nature of sustainability issues. For example, if agencies find they are restricted internally from addressing important aspects of sustainability, this highlights the need for inter-agency cooperation to ensure that the goal is being adequately covered and monitored elsewhere. While this is not an issue that can be directly addressed within the fundamental steps of the framework, it is still necessary for agencies to understand the big-picture issues and to think and work in a holistic manner wherever possible.

Mapping Goals to Sustainability Principles

As mentioned previously, the transportation sustainability goals are viewed as a reflection of general sustainability principles in the transportation sector. Thus, every goal that forms part of the final goal set should have a clear relation to at least one principle of sustainability but could also reflect more than one principle. The four principles as shown in Table 4 can be summarized as:

- Preserving and restoring environmental and ecological systems.
- Fostering community health and vitality.
- Promoting economic development and prosperity.
- Ensuring equity between and among population groups and over generations.

Table 4. Mapping of Transportation Sustainability Goals to Principles of Sustainability.

Goal	Principle			
	Environmental and Ecological Systems*	**Community Health and Vitality***	**Economic Development and Prosperity***	**Equity****
1. Safety				
2. Basic Accessibility				
3. Equity/Equal Mobility				
4. System Efficiency				
5. Security				
6. Prosperity				
7. Economic Viability				
8. Ecosystems				
9. Waste Generation				
10. Resource Consumption				
11. Emissions and Air Quality				

* *Mapping of the goals to the first three principles can be done by using a yes/no binary score, a rating scale, or a comment indicating to what extent the goal addresses the principle.*

** *Mapping of the goals to the equity principle is done by using a qualitative judgment of how equity is addressed in the specific context*

The sustainability goals should be mapped to the first three principles by using a yes/no binary, a rating scale, or just a comment indicating to what extent the goal addresses the principle. The extent to which the goal addresses the principle is highly dependent on the specific context. The final principle (equity), however, is viewed as a special principle that needs to be an integrated part of the framework. Even if a goal relates to one or more of the first three principles (environmental, community health and vitality, and economic development), it can still impact equity in a negative way. For example, the economic and environmental benefits of an initiative taken toward a particular goal can be distributed inequitably or even cause a disbenefit to certain populations or areas. It is therefore important for each goal to be examined in terms of potential equity and distributional impacts. Goals should be mapped to the equity principle only through a qualitative judgment of how equity is addressed in that specific context. Researchers recommend that the following types of equity be assessed, for each goal, both in an intra-generational (i.e., present day) and inter-generational (i.e., future) context:

- Income.
- Age.
- Race and ethnicity.
- Disabled/handicapped populations.
- Gender.
- Geography (spatial).

Table 4 shows a template for the mapping of a selected set of goals (in this case, the 11 recommended goals). An agency would follow a similar approach for their selected goals and fill

in the table to map the goals to the principles. An agency should ensure that the selected set of goals addresses all four principles.

Development of Objectives

The goals developed in the framework are broad and generally applicable to the entire transportation sector. Goal-specific objectives are used to define how the goal can be applied to different aspects of the transportation agency's functions. Objectives are more specific and measureable, and lay the foundation for performance measurement, with measures that can be tied directly to objectives. The development of objectives is an important step that allows sustainability to be implemented in the areas in which a transportation agency generally operates. This framework uses a set of focus areas to classify and describe the broad functions of a transportation agency in support of its core mission/functions. A focus area can be viewed as a generic category that describes a certain type of transportation agency function. Almost anything a transportation agency does that relates to sustainability can be generated within one of these focus areas. While there are other agency functions such as finance, human resources, and interagency liaison to name a few, they do not deliver a transportation agency's core mission. These functions can be considered support functions to the main focus areas. Some transportation agencies may find the focus areas not completely aligned with their structure due to the vast differences among the structure of DOTs and other agencies. Researchers recommend that agencies address these overlaps by selecting objectives and performance measures from multiple focus areas as necessary. Objectives can also be derived from goals without linking them to specific focus areas. The objectives for each goal are developed based on the focus area. The six focus areas as identified in this framework are:

1. Planning.
2. Programming.
3. Project development.
4. Construction.
5. Maintenance.
6. System operations.

The development of the focus areas was based on the general transportation planning and project implementation process described in Chapter 2. The focus areas envisioned in this framework are described as follows:

1. **Planning**—Planning activities include the development of long-range plans, strategies, and frameworks intended to improve one or more functional areas of the transportation system (or the entire system). Documentation resulting from planning activities may highlight a general or categorical set of problems, outline a general program of projects or activities calculated to effect change over time, and provide an estimate of the resources required; it will rarely delve into specific project parameters. Examples may include regional transportation plans, master plans, strategic highway safety plans, and long-range thematic studies or plans. It should also be noted that transportation planning has strong links to land use planning and comprehensive planning, which could be taken into consideration.
2. **Programming**—Programming is the process of determining which set of projects will be funded and the timing of that investment. These decisions are based on the policies, strategies, and other plans identified in the planning focus area. This process must

consider funding availability, may include a project prioritization tool, and often requires broad input from throughout an agency and its partners. Example outcomes may include transportation improvement programs and unified planning work programs.

3. **Project development**—Project development involves defining the specific attributes of the projects selected during the programming area, including alternatives analysis, engineering, design, specifications, environmental and regulatory analysis, and required mitigation. Example outcomes may include alternatives analysis, environmental impact assessments, and project designs.
4. **Construction**—Construction involves building new transportation facilities; the addition or removal of ramps or flyovers; the addition or removal of lanes; and the addition or demolition of bridges, tunnels, or other integrated infrastructure.
5. **Maintenance**—Maintenance activities are broad ranging, and may include routine and preventative maintenance. Significant maintenance and improvement activities such as paving/repaving and major infrastructure improvements such as redecking are also included.
6. **System operations**—Operations include all active or passive non-construction activities or systems dedicated to sustaining or improving the functionality of the transportation network. System operations include network monitoring, signalization and signage, traffic/driver information systems, tolling and managed lanes, speed control and enforcement, parking management, turning and merging permissions and restrictions, incident management, public transportation routing and management, and management of integrated transportation and non-transportation infrastructure.

Implementation of Transportation Sustainability Performance Measures

The implementation of performance measurement is the final step in applying a single iteration of the performance measurement framework. The implementation of transportation sustainability performance measures includes two main components:

- The selection and development of performance measures.
- The application of the measures for the required purpose.

As seen from the detailed framework diagram in Figure 1, these are interrelated elements, with each influencing the other. The underlying concept is that the use of appropriate performance measures is highly context specific and depends upon the purpose for which the performance measures are being applied. The following elements are considered relevant in the implementation of the performance measures:

- Selection and development of performance measures.
- Type of application.
- Level of application.

Selection and Development of Performance Measures

The development of performance measures is closely linked to the development of objectives, and many of them are a small shift to help quantify each objective. Ideal performance measures are easily understood, provide clear indication of moving toward an established goal, and can be tracked using accessible and available data. Sustainability performance measures can be developed to specifically support the defined objectives, but they can also be culled from an

agency's existing practices and compiled to begin to form the basis of a sustainability framework. This strategy allows an agency to build from the ground up, using its existing program as a foundation. After the existing measures have been linked to definite objectives and goals, additional measures can be added over time to round out the program.

A compendium of objectives and performance measures, covering the 11 recommended goals for sustainability, was developed as part of this project. The compendium is described in detail in the next chapter and can be used to identify or develop a set of performance measures. When reviewing the set of performance measures, some may have stronger linkages to sustainability than others. Many measures may also be conventional performance measures that DOTs are currently using to monitor and track progress and agency practices. It must be recognized that no single performance measure is a sustainability measure in isolation. It is the application of a collective set of measures, aligned with the objectives and goals and viewed within the context of the sustainability principles, that makes the measures relevant to a sustainability framework.

Most of the performance measures selected for inclusion in this framework and compendium are those that relate to the functions of a transportation agency's core business (i.e., within the purview of the focus areas). These are distinct from performance measures that may relate to transportation yet only reflect an agency's internal initiatives, and could be implemented by any type of agency or organization. An example would be a performance measure of employee use of transit or telecommuting. These types of performance measures, termed organizational transportation sustainability performance measures, are considered only an auxiliary part of the framework and feed into the section of the framework on auxiliary organizational initiatives. Due to the overlap between transportation-related organizational measures and broader transportation sustainability measures, some of the performance measures identified may also have organizational applicability and are highlighted as such in the compendium.

Classification of Performance Measures. Sometimes performance measures for a transportation agency are discussed in terms of those at the system level versus those at the agency level. Organizations also sometimes discuss performance measures as being internal or external. Such distinctions are often not very clear, though they aim at classifying performance measures that might be within an agency's control (internal or agency performance measures) versus those that are outside of an agency's immediate sphere of influence (system or external performance measures). However, a better approach to considering the degree of control an agency has in the classification of performance measures is to subdivide them as outcome measures, output measures, and process measures. This is a simple classification that captures how agency actions (processes) can result in changes (outputs) that may ultimately influence progress toward goals (outcomes). The following provides definitions of the three performance measure classifications:

- **Outcome measures**—Outcome measures provide information on the achievement of broad goals, such as transportation sustainability goals. These measure the result or impact of a program, policy, infrastructure decision, etc.
- **Output measures**—Output measures relate to results or changes in terms of the transportation system and its functioning. These measure a product or concrete item that results from a process action.

- **Process measures**—Process measures relate to inputs or products related to a transportation agency's activities. These measure components of an agency practice that are deemed to support the related objective.

Table 5 shows an example of outcome, output, and process measures that support the same sustainability goal.

Table 5. Example of Outcome, Output and Process Measures

Goal: Reduce waste generated by transportation-related activity	
Outcome Measure Example	Change in the amount of waste generated by type, weight, and/or volume
Output Measure Example	Change in the percentage of operational activities with a recycling plan or waste diversion goal
Process Measure Example	An asset management system exists

Application Levels

The application of the framework can be done at the level of the whole agency or at the level of individual components of the agency—for either focus areas or business units. Ideally, both are required (i.e., a top-down and bottom-up approach) to promote strategic and operational decisions in support of sustainability. The application at each level is described below.

Application for Focus Areas and Business Units. The application of the framework within the various operational arms of the agency varies from agency to agency. This framework considers this in terms of two elements—focus areas and business units—that may overlap to varying degrees in different agencies and contexts. The focus areas are the generic categories defined previously, which are used in classifying the objectives and performance measures. Business units refer to specific divisions or sections in an agency that might be tasked with implementing performance measurement for sustainability in their particular area. The business units have not been categorized and described because of the vast differences observed in agency structures, even among agencies of the same type. The boundaries of a particular business unit may or may not coincide with the focus areas prescribed in the framework. The application of the framework and selection of performance measures need to consider both of these elements.

To develop performance measures for application, specific business units should identify which of the goals they contribute to. This performs two roles. First, the agency's sustainability coordinator can understand which agency activities impact which goals. If no activities impact a specific goal, then it may be that core business activities are not being interpreted broadly enough, or the goal, while appealing, may have little organizational relevance and could be removed. For example, the street lighting section may have strong connection only to goals related to non-renewable energy and safety. Construction activities may focus on waste generation, emissions, and environmental protection. The goals will be subject to selection of objectives and indicators specific to that business unit, and the compendium of objectives and measures for the recommended goals can provide guidance and may be equally applicable to a revised set of goals identified by a particular agency. In the absence of appropriate objectives and

performance measures for certain goals, additional measures may need to be identified. In cases where multiple or overlapping performance measures across an agency contribute toward the same goals due to the application for focus areas or business units, some level of standardization is necessary and desirable (for example, in carbon footprint calculation).

Application for the Entire Agency. The application of the framework for an entire agency can include top-down applications that examine the various focus areas or agency units, as well as the development of strategic direction on sustainability for the entire agency. The application of the framework for the entire agency is very important to provide a unified approach to sustainability in terms of agency goals and objectives, which business units or other entities within the agency can then pursue in their individual areas.

The application for the entire agency can include performance measurement and reporting across focus areas and agency divisions to identify areas for improvement. The agency's approach and understanding of the implementation of sustainability are developed and improved (by iteration) through interaction with the agency units, for which a clear reporting framework needs to be established. It is also important for the framework to influence important strategic decisions rather than just the detailed implementation practices at the agency unit level. This can be done, for example, through the development and application of sustainability reporting scorecards, which are supplied and discussed as part of all major board-level decisions.

Application Types

Application types refer to the use of the performance measures as part of the framework—whether it is to be used by the agency for decision support, communication, promotion of accountability, etc. The application type often determines the type of performance measures to be selected. Each of the application types has certain methods/approaches/application frameworks and typologies that may be more relevant than others. The level of application can drive the selection of application types and vice versa. There are five types of applications identified for the sustainability performance measures discussed in this evaluation and implementation framework:

- Description.
- Evaluation.
- Accountability.
- Decision support.
- Communication.

These applications are not necessarily sequential, but they represent broad areas of use of performance measures from a transportation agency perspective. The next chapter of this report discusses each application type in detail and gives further guidance and examples.

Feedback

The framework application in terms of the fundamental components does not represent the termination of the sustainability assessment and performance measurement process. Feedback information on whether the decisions are leading to the desired/intended outcomes is an essential

part of the process and must lead to refinements of the framework to ensure continual improvement.

OVERARCHING FRAMEWORK COMPONENTS

Overarching framework components are elements that need to be considered throughout the framework application process. These include stakeholder engagement and participation and coordination with external agencies. These touch upon the fact that the framework should not look at the transportation sector in isolation, but must coordinate with external entities and stakeholders. Organizations can leverage each other's work when it comes to sustainability, through joint projects, shared expertise, shared resources, and cost savings obtained by matching funds and shared efforts such as through public involvement. Cross-sectoral issues should also be dealt with in the coordination with external agencies and in engagement with stakeholders. For example, transportation agencies can coordinate with land use planners on carbon dioxide mitigation efforts, or with health agencies in promoting walking and walkability. These steps ensure that transportation is not addressed in isolation by the framework. Stakeholder engagement and participation is necessary when completing the tasks of understanding sustainability, developing the goals, and reviewing the framework, over and above stakeholder involvement in the identification and selection of performance measures.

Auxiliary Framework Components

Auxiliary framework components are optional components that can be used to supplement the framework application process. These include the following components, which are also explained briefly below:

- Agency definition of sustainability.
- Organizational sustainability initiatives.
- Organizational transportation sustainability indicators.

Agency Definition of Sustainability

Developing a definition of sustainability is encouraged to help agencies better understand how the principles of sustainability apply to them but, as discussed earlier, does not form a part of the fundamental framework application process. The decision to develop an agency-wide definition or statement on sustainability can help target sustainability at a strategic level. Some agencies may want to develop a definition of sustainability for a variety of reasons, including ensuring buy-in from management, staff, or key stakeholders. Here, an agency's definition of sustainability is considered to encompass their understanding of what sustainability is as well as their intent in applying concepts of sustainability.

In terms of developing a definition, the preferred approach would be for an agency to commit to sustainability as a strategic or overarching direction, rather than discussing sustainability in terms of a sustainable transportation system. Appendix D contains guidance for an agency to define sustainability for use in agency-wide initiatives. Each agency needs to define its own understanding, approach, and priorities with regard to sustainability, based on the principles of sustainability and the agency's specific concerns, needs, and contexts.

Organizational Sustainability Initiatives

The term "organizational sustainability initiatives" is used to represent actions that transportation agencies can take toward sustainability that do not fall directly into the realm of transportation-related performance measurement and application. These can be viewed as sustainability initiatives taken by the agency unrelated to its function as a transportation agency, but rather applicable to any organization. This includes internal sustainability initiatives such as the use of energy-efficient appliances, recycling of paper, responsible purchasing of office supplies, etc., and can also include components of agency initiatives (such as an agency sustainability plan or climate action plan) that are internal to the agency. While such agency buy-in to sustainability is an important concept, it plays an auxiliary role given the purpose of this framework.

Organizational Transportation Sustainability Performance Measures

Organizational transportation sustainability performance measures are applicable to any organization and are an auxiliary component of the framework. These measures can be applied to any organization, not just a transportation agency, and therefore do not necessarily relate to the transportation agency's core function. As discussed under the fundamental framework components, organizational transportation sustainability performance measures are often special cases/application of broader sectoral transportation sustainability performance measures and are therefore briefly addressed as part of the compendium of objectives and measures.

FRAMEWORK REVIEW AND IMPLEMENTATION

Prior to implementation, a thorough review of the framework is desirable to ensure a comprehensive and robust approach to sustainability. The framework should be reviewed in terms of the entire process being applied, starting with an understanding of sustainability and working to the development of goals, objectives, and measures. The framework review should also be performed for individual business units that apply the framework in their particular area of functioning.

The framework review should ensure that each of the principles is covered and that the coverage (by not only the goals but also objectives and measures) is not disproportionately weighted to one principle. It should be reflected and explained explicitly if there is a purposeful emphasis/de-emphasis on some principles. The whole agency sustainability strategy should be described and developed around this set of top-level principles and goals. Upon implementation of the framework, feedback based on the outcome and effectiveness of resulting decisions should drive further refinements to the framework.

Agencies must use the opportunity to collaborate with external agencies in a synergistic manner. Stakeholder input is also a vital part of the framework development process. The framework review provides the opportunity to include external agencies and groups in the review process. These entities can help the agency search for potential avenues for collaboration that can save costs, pool resources, and share expertise/knowledge in the case of multiple agencies working toward common sustainability goals.

CONCLUDING REMARKS

This chapter describes a framework in the form of fundamental steps along with several overarching and auxiliary components. The fundamental steps include developing an understanding of sustainability, identifying appropriate sustainability goals that are also relevant from a sustainability perspective, and identifying suitable objectives and performance measures to operationalize the process for selected focus areas and business units within an agency or for an agency as a whole. The next chapter provides discussion of the application of performance measures in this framework.

CHAPTER 4—APPLICATION OF PERFORMANCE MEASURES

The implementation of performance measures was discussed in the previous chapter and covered two major components: the selection and development of appropriate performance measures, based on type of application, level of application, and other context-specific considerations; and the actual application of performance measures for various purposes, such as for description, evaluation, decision support, assignment of accountability, and communication. This chapter describes the development of a compendium of performance measures to support the application of the framework and also discusses the various application types with examples.

PERFORMANCE MEASUREMENT COMPENDIUM

The sustainability performance measures compendium developed for this project is intended to provide agencies with proposed goals, objectives, and performance measures that can be used to apply the framework developed in Chapter 3. The compendium offers examples of what those objectives and measures might be and how they fit together. Depending on agency type, context, focus, and organizational structure, the goals, objectives, and measures can be adjusted to fit with the localized need. The 11 recommended goals were used as the foundation for identifying the objectives and measures. Under each goal, a set of objectives for each focus area was developed. The performance measures compendium essentially serves as a source table of goals, objectives, and measures available to agencies as a resource involved in identification or utilization of performance measures. The tables of the performance measures compendium are provided in Appendix E of this report. An electronic version of the compendium (in a Microsoft® Excel spreadsheet format) is included with the guidebook and allows users to search and filter out measures based on the classifications described below.

The performance measures included in the compendium were chosen to support the set of selected objectives. They were compiled from the literature review, case study agency examples, and experience of the project team. The research team used the following attributes in selecting the proposed performance measures:

- General acceptance of validity in the industry.
- Relevance to and representation of related objectives and goals.
- Assumption that data can be obtained to quantify the measure.
- Responsiveness of the measure.

After the objectives and measures were identified by the project team, the database was compiled and reviewed for consistency, redundancy, use of language, and other potential issues. After this review was complete, the project team consolidated the measures and created a set of classifications to add functionality and depth to the compendium. The classifications are described as follows:

1. **Focus area**—As previously mentioned, the objectives are developed for six focus areas: planning, programming, project development, construction, maintenance, and operations. The measures are also developed and classified per focus area.
2. **Measure type**—This classification includes two dimensions: whether the measure is applicable at the organizational level (e.g., is not specific to the transportation function of a transportation agency, such as an employee telecommuting policy, which can be

instituted by any agency, not necessarily a transportation agency); and whether it is an outcome, output, or process measure (both explained in Chapter 3).

3. **Program relevance**—This classification provides further information on how each measure may support other considerations for a transportation agency in the important areas of:
   - Freight.
   - Transit.
   - Bicycle/pedestrian.
   - Safety.
   - Land use.
4. **Principles**—This classification links each of the measures to one or more of the four sustainability principles identified in the framework:
   - Environment.
   - Community health and vitality.
   - Economy.
   - Equity.

APPLICATION TYPES

This research seeks to provide guidance for transportation agencies desiring to implement performance measurement for sustainability. Performance measurement application is particularly important in attempting to address what agencies, stakeholders, decision makers, or others might wish to know about a transportation agency's practices or results. The most common questions would relate to:

- Is the agency improving in making sustainability part of its policies, programs, and practices?
- Is the agency, or one or more of its programs, functions, or actions, achieving a desired level of sustainability?
- How do two or more alternative options compare relative to the agency's desired sustainability objectives (for the agency or specific program, practice, or action)?
- Are an agency's actions meeting its goals for those types of actions?

These questions can be addressed through the following five application types as introduced in Chapter 3:

- Description.
- Evaluation.
- Accountability.
- Decision support.
- Communication.

These five application types, identified through the literature review and case studies, cover the range of possible scenarios of what an agency might want to do in terms of selecting and applying performance measures (in this case, specifically relating to sustainability). Note that these application types are not mutually exclusive; some performance measures may be used for more than one application. While some may be applied sequentially, they could also be used

independently, as illustrated in Figure 4. Some applications derive logically from one another (for example, evaluation can be viewed as an extension of description; similarly, accountability or decision support follows logically from an evaluation exercise). Communication, on the other hand, is more an overarching application that is implied in the use of other applications but is also an application in itself. These five types of applications form the basis for how performance measurement will be applied and are described briefly below with generic examples. There are many real-life examples of transportation agencies using performance measures in the five types of applications, both in terms of sustainability performance measures and other performance measures. Appendix F contains selected practical examples of how transportation agencies use performance measures for different applications.

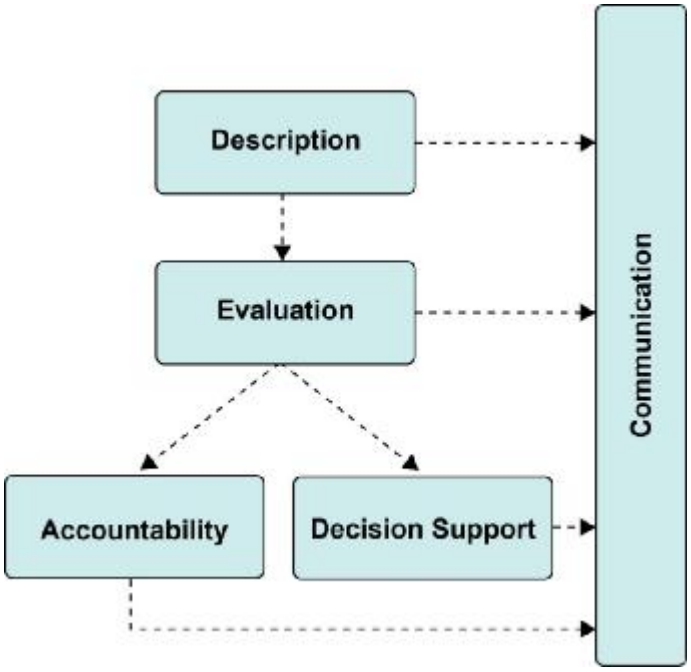

Figure 4. Relationship between Application Types.

Application Type 1: Description

The purpose of this application type is to characterize aspects of the transportation system, agency business, or actions. This is often done in terms of current status and trends. It helps an agency explain the levels at which its programs, facilities, and services are performing through relevant measures.

Some examples are:

- Public transportation ridership.
- Number of ozone action days.
- Daily or hourly traffic volumes.
- Pavement conditions.
- Costs of environmental mitigation actions/programs

Application Type 2: Evaluation

This application type differs from the previous type in that it introduces a normative component; that is, it introduces a value against which the current performance and trends are compared. Evaluation involves the use of targets, benchmarks, comparisons, or trends. The purpose of this application is to help agencies identify progress, problems, or shortcomings relating to aspects of the transportation system or to the agency's programs and initiatives. Comparisons can be made based on benchmarks/targets, other agencies' progress, or existing national/statewide averages for selected performance measures. This type of application may also be used as a tool to identify the causes of a particular problem and how well possible remedies may improve performance.

Some examples are:

- Highway fatalities compared to the national average.
- Project development duration compared to a target duration.
- Travel-time ratio of peak to off-peak times compared to the national average for urban areas.
- Regional vehicular emissions compared to a regional on-road mobile source budget.
- Agency budget for capacity improvement projects compared to the estimated cost of needs.
- Pavement index scores, which indicate pavement condition problems—the agency identifies sections of the road network with poor scores and breaks down the scores of identified sections to determine specific deficiencies.
- Traffic incidents per roadway segment—the agency breaks down the data by incident type to determine where to focus efforts and what types of incidents to address.

Application Type 3: Accountability

The purpose of this application is to identify the level of performance for which an agency or unit is responsible and what it is achieving. This application can also be used to identify the level of performance in a priority area and whether improvement is needed. This application can identify the performance of agency units or other entities against targets, norms, or baselines.

Some examples are:

- Average change order cost percentages by district.
- Percent of projects processed through the NEPA process within a target time period.
- Portion of construction or maintenance contracts completed on schedule by the construction division and maintenance division, respectively.
- Percent of transit runs completed on schedule by the transit agency.
- Percent of fleet fuel consumption from renewable fuels by districts.

Application Type 4: Decision Support

The purpose of this application is to support decision making by helping to evaluate, compare, prioritize, and select among alternatives and options in terms of sustainability considerations. Some applications determine whether or not to proceed with a proposed action or to select

among alternatives. Other applications may compare performance to a target to aid decisions to continue or modify a program, practice, or project.

Some examples are:

- Evaluating alternatives such as alignment selection or capacity addition versus demand management.
- Prioritizing projects for programming.
- Evaluating feasibility of project alternatives through benefit-cost ratios or life cycle cost analyses.
- Selecting preferred environmental mitigation actions.
- Selecting which system problem segments or locations to address first.

Application Type 5: Communication

Any use of performance measures involves some form of communication. Hence, communication is a supporting (or reporting) function for all previously described functions. Communication to internal and external stakeholders can also be a purpose in itself and can help to effectively disseminate the results of performance measurement and the applications of performance measurement.

Some examples are:

- Performance measures can be communicated to report findings from one of the four above applications through:
  - Indices.
  - Numbers.
  - Tables.
  - Graphs.
  - Scorecards.
  - Dashboards.
  - Other numerical or graphic methods.
- The most frequently used methods show conditions, comparisons, trends, and adherence to targets, goals, and objectives. They may be reported within presentations, reports, articles, papers, handouts, email blasts, website information, outreach and education campaigns, and other such means.

RATING SYSTEMS TO SUPPORT PERFORMANCE MEASUREMENT APPLICATIONS

As mentioned in Chapter 2, another application of sustainability performance measures in the transportation sector involves the use of rating systems for sustainability. In general, a rating system for transportation sustainability provides a framework for scoring and evaluating various projects or alternatives. Appendix G discusses the key attributes of rating systems for sustainability and discusses the steps involved in creating and establishing such a system using appropriate performance measures. Rating systems are not an application type but can potentially be used to support the application types. For example, the output of a rating system can be used to evaluate options, support decisions, or communicate sustainability scores to the public. The advantage of developing a rating system to support sustainability performance measurement is

that it provides standardized metrics for measuring sustainability. While there are potential problems with the development and use of rating systems (including loss of detail and lack of consensus on which attributes to include), rating systems are still being increasingly implemented for standardized scoring and measurement based on sustainability attributes.

CONCLUDING REMARKS

This chapter provided additional guidance and resources for the actual application of performance measures using the framework presented in Chapter 3. Performance measures can be used for various purposes, such as for description, evaluation, decision support, communication, or assignment of accountability. A compendium of performance measures was developed as part of this research and provides examples covering a range of goals and objectives. The measures in the compendium are further classified according to the type of performance measure and focus area. Other categorizations of the measures, for example, based on principles addressed or program relevance categories, can help to identify and define appropriate measures depending upon the context. Examples of the different performance measurement applications were provided in this chapter, along with a discussion of the potential use of sustainability rating systems. The guidebook developed as a companion piece to this report contains more information on the practical implementation of performance measures for sustainability.

CHAPTER 5—CONCLUSIONS AND RECOMMENDATIONS

CONCLUDING REMARKS

This project developed guidance for state DOTs and other transportation agencies to understand and apply concepts of sustainability through performance measurement to enhance their activities in areas such as planning, programming, project development, system operations, and maintenance. The purpose was to develop a guide that is flexible and can be used by a range of transportation agencies for specific contexts.

As part of this project, the research team conducted a detailed literature review covering the topics of sustainability and sustainable development, sustainability in the transportation context, performance measurement, and the use of performance measures for sustainability. A state-of-the-practice assessment including case studies and interviews with selected agencies was also performed. A flexible, generally applicable framework was developed to provide transportation agencies with the tools required to apply sustainability through performance measurement. A key feature of this framework is that it promotes the holistic consideration of transportation and sustainability. The framework can be applied/adapted for use in a broad range of transportation agencies and at any level within such agencies. The framework defines transportation goals that can be broken down into a menu of objectives and performance measures to cover various transportation contexts. The framework is also designed to direct an agency's strategic planning toward the practical implementation of sustainability through performance measurement, and encourages the coordination with partner agencies and stakeholders. The application of sustainability performance measures for a range of application types—to describe, evaluate, support decisions, promote accountability, or communicate—was also discussed. The research also identified examples, tools, and approaches to applying sustainability.

Apart from this research report, which documents the primary findings, research approach, and methodology, there are two additional research products from this project: a user-friendly guidebook for transportation agencies and a spreadsheet-based electronic compendium of performance measures, which accompanies the guidebook. It is expected that these research products will together provide transportation agencies with background information on sustainability in the context of transportation, and the information and resources needed to successfully tailor and implement a sustainability performance measurement system.

Nearing completion of this project, the research team conducted two interactive practitioner workshops based on the suggestions of project panel members. These workshops involved two groups of transportation professionals (from the Texas Department of Transportation, ODOT, and the FHWA regional office in Texas). The workshops covered the research approach and background in an instructional format, followed by an interactive exercise and open discussion. Appendix H summarizes the workshops. These workshops assessed the applicability and usefulness of the framework and guidebook, and identified future research needs to build off this research. Overall, the feedback from the workshops confirmed that the framework and guidance developed were useful, understandable, and applicable to a broad range of transportation professionals and transportation agencies. The remainder of this chapter discusses the possible avenues for dissemination of the research and the future research needs identified.

AVENUES FOR DISSEMINATION OF RESEARCH

During the course of this project, the research team presented the preliminary findings of the research through journal papers, workshops, and presentations. Activities resulting in the dissemination of the research to date include:

- Presentation at the 90th Annual Meeting of TRB in Washington, D.C., in January 2011.
- Journal paper accepted for publication in the *Transportation Research Record* (based on the paper presented at the 2011 TRB annual meeting).
- Presentation at the Association of Governors Conference in Seattle, Washington, in November 2010.
- Presentation at the TRB Conference on Transportation Planning, Land Use, and Air Quality in San Antonio, Texas, in May 2011.
- Poster presentation at the TRB Fourth International Transportation Systems Performance Measurement Conference in Irvine, California, in May 2011.
- Presentation accepted for the Air and Waste Management Association 10th Annual Conference in Orlando, Florida, in June 2011.
- Interactive workshops conducted for practitioners in Texas and Oregon based on the research results and guidebook materials.

The final products from this research include the final project report and the published guidebook. PowerPoint® presentation materials will also be produced, which can be used for information dissemination. Possible future avenues for dissemination include:

- Presentation at the 2012 TRB Annual Meeting and a one-day workshop or training session in conjunction with the 2012 Annual Meeting.
- Journal articles and research papers.
- Presentations at conferences and meetings including at American Planning Association (APA), Association of Metropolitan Planning Organizations (AMPO), AASHTO, and Institute of Transportation Engineers (ITE) meetings.
- TRB-sponsored webinars.
- Training for state and other transportation agencies' staff, including:
  - FHWA/National Highways Institute (NHI).
  - AASHTO.
  - State DOTs.
  - AMPO.
  - APA.
  - American Public Works Association (APWA).
  - ITE.
  - Other organizations emphasizing sustainability.
  - University extensions.
- Inclusion in university curricula as a teaching module for transportation planning/decision-making courses.
- Dissemination on websites/web-based communities, such as AASHTO's Center for Environmental Excellence, and websites/mailing lists of TRB committees and subcommittees, such as the committee on sustainability (ADD40), subcommittee on sustainable transportation indicators (ADD40[1]), and committee on performance measurement (ABC30).

FUTURE RESEARCH NEEDS

This project equips transportation agencies with background information on sustainability in the context of transportation, and the information and resources needed to successfully tailor and implement a sustainability performance measurement system. Therefore, this research provides the foundation for transportation agencies to address sustainability through performance measurement. During the course of the project, a set of research needs was identified that would further enhance the application of sustainability in transportation agencies. The research team used the project findings, their own experience, and the results of the practitioner workshops (summarized in Appendix H) to identify the future research needs. The research needs identified were classified into five broad themes, which are discussed briefly below.

Improved Tools, Methodologies, and Applications

The research needs identified in this topic cover the measurement or quantification aspects of performance measurement, as well as the need for tools to aid in application of the measures (for example, in decision support). Specific needs include comprehensive or standardized data sources and computation methodologies, guidance on validation of the performance metrics (i.e., to answer the question of how specific measures translate to sustainability outcomes), and decision-support tools and processes that integrate performance measurement. The electronic compendium tool developed in this project can be expanded and enhanced into a database format for a more streamlined presentation that can address some of the needs identified here.

Training and Capacity Building

Capacity building and training for applying sustainability performance measurement involve translating findings from academic research into the appropriate context for practical implementation by transportation agencies. The guidebook developed as part of this project is a good example of such an initiative. However, research is needed on building training modules that address specific needs and concerns, facilitating the implementation of sustainability performance metrics into practice, and growing the expertise among transportation practitioners. Another aspect is the development of course material that can be included in university curricula at the graduate level.

Strategic Planning for Sustainability

In developing the framework in this research, it was seen that the goals and mission of a transportation agency (as reflected in its strategic plan) often influence and drive any performance measurement initiatives. Research is needed to address how transportation agencies can work to integrate sustainability into strategic planning in a manner that avoids conflicting or redundant goals or metrics and instead promotes a culture of sustainability within an agency. A potential area of focus is examining how frameworks for sustainability, such as those proposed in this project, can be applied for decision making at higher levels of an agency.

Integration over Multiple Sectors

As discussed in this report, sustainability entails looking beyond the transportation sector. In the framework developed, the need for going beyond the transportation sector was reflected in the

emphasis on interagency coordination and working with partners as an overarching part of the framework. However, research needs to be done on potential approaches that would allow multiple sectors to address sustainability in a unified manner, keeping in mind the existing policy and legislative frameworks at the relevant level (local/state or national).

Legislative and Policy Directions

The research needs identified in the previous categories dealt with addressing sustainability within the realm of existing agency and governance structures and associated policies. Another avenue for future research is regarding transportation policy, linkages to sustainability, and the impact of potential policy and legislative changes that may affect transportation and transportation system sustainability. Questions to explore would include whether approaches, tools, methodologies, and metrics for sustainability differ in different legislative and policy contexts.

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APPENDIX B—GLOSSARY OF KEY SUSTAINABILITY TERMS

Biogeophysical Sustainability – Biogeophysical sustainability is the maintenance and/or improvement of the integrity of the life-support systems on Earth.

Earth's Life Support Systems – Natural systems that support life on Earth; the atmosphere, the waters, the soils; ecosystems that provide essential services, such as food, energy, waste decomposition, and pollination of plants.

Eco-Efficiency – World Business Council for Sustainable Development (WBCSD) describes eco-efficiency as a management strategy of doing more with less. In practice, eco-efficiency is achieved through the pursuit of three core objectives: increasing product or service value; optimizing the use of resources; and reducing environmental impact. Eco-efficiency is only a relative measure, by some seen as a necessary, but not sufficient condition for achieving sustainability, as in some case, absolute reductions in some environmental pressures are needed.

Ecological Economics – Ecological economics is a transdisciplinary field of study that combines the economy and technology with ecology. It studies the relationships between ecosystems and economic systems, encompassing both biological and cultural change.

Ecological Modernization – Ecological modernization refers to the transformation or adaption of industrial systems to reduce their environmental impacts. The concept focuses on material and energy productivity gains through actions such as product and process innovations, supply chain management improvements, and the replacement of hazardous chemicals with non-toxic substitutes.

Equity/Equitable Distribution among Population Groups – Equity concerns the distribution of access to facilities (e.g., jobs and leisure), benefits from investment decisions, and exposure to the negative externalities generated by transport. Equitable policies are those which both promote social progress and lead to a narrowing of the gap between groups that have the best and worst of current conditions. Progressive policies close the gap between the true marginal social cost of journeys and the prices paid by travelers.

Human Needs (Basic) – Basic human needs can be grouped into four general areas that can be used to consider the motivation, functioning, and well-being of humans. These areas are: 1) safety, security, and sustenance; 2) competence, efficacy, and self-esteem; 3) autonomy and authenticity; and 4) connectedness. The satisfiers to these needs are defined by economic, social, and political systems. Thus, they differ across cultures and change over time.

Impact (Cost/Benefit) – Effect or consequence of something. Impact is the effects (desirable or undesirable) of some activity or influence on entities of human concern. Impact is often seen as the terminal point of a causal chain, following intermediate steps such as pressure on and change in the state of a system or entity. For example, a disturbance (pressure) on a traffic flow may change the average speed (state), leading to time losses (impact). Impacts are therefore the ultimate concern for policy or project assessment. Impacts can be positive or negative. Impacts are sometimes aggregated into categories depending on the domain in which they occur (e.g.,

environmental impacts, economics impacts) or on their value to human society (costs or benefits).

Indicators – Indicators are measurable entities or variables that can be used to evaluate progress toward achievement of a goal or objective. While often used interchangeably with "performance measures," indicators typically provide an idea of general direction of performance, without the introduction of specific units or benchmarks.

Industrial Ecology – Industrial ecology is the study of material and energy uses and flows in products, processes, and industrial systems. It focuses on ways to reduce negative environmental impacts from industrial activity using techniques such as life-cycle analysis.

Livability – Livability captures the degree to which integrated transport and land-use planning initiatives contribute to communities with high environmental quality, which promote walking, cycling, and public transport use and easy access to local amenities.

Management of Resources – Management of resources refers to the prudent use of non-renewable resources that are currently used as inputs to the transport system (e.g., construction materials and fuels). The general direction of change is to use less non-renewable resources and to use renewable resources at rates no greater than that at which they can be replaced.

Natural Capital – Natural capital is the stock of all environmental and natural resource assets. It consists of three main categories: 1) non-renewable resources; 2) renewable resources; and 3) the capacity of natural systems to absorb emissions and pollutants from human activity.

Performance Measures – Performance measures are quantifiable indicators of performance that can be used to evaluate progress toward achievement of a goal or objective. While often used interchangeably with "indicator," performance measures generally denote the presence of specific quantification mechanisms, units, and implied targets/benchmarks.

Quality of Life – Quality of life at the community level or individual level encompasses aspects that go beyond basic human needs for survival – for example, health, comfort and convenience, safety, security, quality of community and social interactions. Indicators for quality of life are highly context specific and are typically defined by a significant community engagement exercise.

Steady-State Economy – A steady-state economy (SSE) is one where the throughput of all raw materials and waste are kept to levels within the regenerative and assimilative capacity of the ecosystem. Within the SSE, technology, knowledge, the distribution of income, and the allocation of resources are fluid. Since a fixed amount of resources will yield a constant flow of goods and services (all else being equal), technological progress is one way in which more (or more highly valued) goods and services can be produced.

Strong Sustainability – Strong sustainability means assuming that environmental resources and systems, or the "natural capital," cannot be replaced by artificial systems and resources, or "man made capital," without detriment to sustainability. To ensure sustainable development, it is

necessary to preserve the natural capital intact, and therefore to measure it in natural rather than economic units.

Sustainability – Sustainability emphasizes the need to balance human needs with consideration of the natural environment and equity issues, in both a present (intra-generational) and future (inter-generational) context. Sustainability is generally discussed in terms of three dimensions: economic, environmental, and social (equity). The distinction between sustainability and sustainable development is usually made by considering sustainability to be an idealized end state and sustainable development as the process of moving toward it.

Sustainable Development – Sustainable development can be viewed as a process of working toward achievement of sustainability, with a particular focus on human needs. Traditionally, it is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

Weak Sustainability – Weak sustainability means assuming that man-made capital (machines, technology, etc.) in principle can replace natural capital when the latter is consumed or depleted, provided the former is able to produce an equivalent economic value to society over time. According to this assumption it is not the natural resources or systems per se that matter for sustainable development, by the welfare they are able to produce for society.

APPENDIX C—CASE STUDY DETAILS AND METHODOLOGIES

INITIAL SCREENING OF CASE STUDY CANDIDATE AGENCIES

A preliminary list of candidate agencies was created through research team knowledge, a literature review, outreach to colleagues with experience in this topic area, and supporting web-based searches. General information about each agency's activities was documented, and in the case of agencies where sufficient information was not available, a short screening interview was conducted to document practices and identify whether the agency would be a suitable case study candidate.

Table C1 lists all the candidate agencies considered for research as case studies. The table indicates the area in which each agency has employed sustainability strategies (the broad categories considered were strategic management, long-range planning and programming, project development and design, construction, and operations and maintenance) and whether or not the agency is recommended for inclusion in this project as a case study agency.

Table C1. Case Study Candidate Agencies Reviewed.

Agency	Location	Strategic Management	Long-Range Planning & Programming	Project Development & Design	Construction	Operations & Maintenance	Recommended Case study?
State DOTs							
Maryland DOT	Maryland		X				
New Jersey DOT	New Jersey		X				
Minnesota DOT	Minnesota		X				Yes
Wisconsin DOT	Wisconsin		X		X		
Caltrans	California	X	X				Yes
Washington State DOT	Washington	X			X	X	Yes
Oregon DOT	Oregon	X	X			X	Yes
Colorado DOT	Colorado					X	Yes
New York State DOT	New York				X		Yes
Florida DOT	Florida	X	X				
MPOs							
North Jersey Transportation Planning Authority (NJTPA)	Northern New Jersey		X	X			
California Partnership for the San Joaquin Valley	San Joaquin Valley, CA	X					
Metropolitan Transportation Commission (MTC)	San Francisco Bay Area	X	X				
San Diego Association of Governments (SANDAG)	San Diego, CA, metropolitan area		X				
Denver Regional Council of Governments (DRCOG)	Denver, CO, metropolitan area		X				
Chicago Metropolitan Agency for Planning	Chicago, IL, metropolitan area	X	X	X			Combined with Regional Transit Authority (RTA) case study
Mid-Ohio Regional Planning Commission	Central Ohio		X				Yes
Metropolitan Washington Council of Governments	Washington, DC, metropolitan area	X					Yes
Transit Agencies							
Los Angeles Metropolitan Transit Authority	Los Angeles, CA		X		X	X	
New York Metropolitan Transit Authority (NYMTA)	New York, NY					X	Combined with PlaNYC case study

Agency	Location	Strategic Management	Long-Range Planning & Programming	Project Development & Design	Construction	Operations & Maintenance	Recommended Case study?
Regional Transit Authority	Chicago, IL	X					Combined with CMAP case study
Hampton Roads Transit	Hampton Roads, VA					X	Yes
International Agencies							
Transport for London	London, United Kingdom				X	X	
Oslo Metropolitan Area	Norway		X				
Transit New Zealand	New Zealand	X				X	
Highway Agencies—United Kingdom	United Kingdom				X	X	Combined with U.K. Rail
U.K. Rail Industries	United Kingdom					X	Combined with U.K. Highway Agencies
National Transportation Agencies	Sweden						Yes
Local Municipalities							
New York City DOT	New York, NY						
PlaNYC	New York, NY	X	X				Combined with NYMTA case study
Alexandria Eco-City Project	Alexandria, VA	X	X				Yes

A short description of each agency's sustainability efforts gathered from available literature and from preliminary screening interviews is presented below.

State DOTs

Maryland DOT—Freight Plan and Attainment Report—Sustainability is mentioned as one of the overall goals in Maryland's Freight Plan, and environmental stewardship/development goals were used as one of five criteria to rank projects and were given a 10 percent weight. Maryland's annual Attainment Report presents performance results on Maryland's multimodal transportation network and shows progress toward strategic goals. The report does not track any goals labeled as sustainability but has related goals such as environmental stewardship and connectivity for daily life.

New Jersey DOT—New Jersey Quality Initiative—A coalition of governmental and non-governmental participants in the state's transportation industry have a partnering agreement. The agreement outlines a number of practices that address the needs of transportation system users, communities, and neighbors. The agreement also outlines practices that promote sustainable environmental quality.

Minnesota DOT—2009 State Plan—The Minnesota DOT's 2009 State Plan defines the agency's vision as "creat[ing] a safe, efficient, and sustainable transportation system." In addition, sustainability and environmental concerns are addressed in two of the plan's policies. Each of these policies has measures that are used to track its implementation. To date, the agency has focused primarily on actions that it can take internally to conserve resources but is looking forward to expanding that sphere of sustainability programs.

Wisconsin DOT—Long-Range Transportation Plan—Wisconsin's LRTP covers sustainability from an economic and fuel usage perspective related to the cost of transportation: "partner with consumers and businesses to increase transportation sustainability." Goals include tracking changes and analyzing responses to the state's transportation energy use and costs; promoting more efficient use of petroleum-based fuels and viable alternatives; encouraging local governments to improve vehicle efficiencies; and seeking to adjust the Wisconsin DOT's transportation revenue stream to respond to changing fuel usage (see page 7–47 of the LRTP for more details).

Wisconsin DOT and the University of Wisconsin—The Madison Civil Engineering Department is developing a green-roads rating system for the state, similar to the set of Leadership in Energy and Environmental Design (LEED) standards developed by the U.S. Green Building Council, partially based on the Greenroads program from Washington State.

Caltrans—Caltrans has been one of the national leaders in considering performance measures in the context of a sustainability framework, as part of the vision that was adopted in the 2025 California Transportation Plan. Environmental quality is one of the three cornerstones of the sustainability framework guiding transportation investment in the state, along with a prosperous economy and social equity.

Washington State DOT—WSDOT, through a state-prescribed system, is required to update an annual sustainability action plan to incorporate sustainable business practices into agency

practices. This plan highlights trends in resource use, identifies policies implemented, and targets goals in the areas of fuel efficiency, energy use, waste management, and toxic chemicals. Also, the Washington State Department of Ecology looked at how to include climate change in the State Environmental Policy Act.

Oregon DOT—In 2004, the department created a Sustainability Program with dedicated staff and resources to manage assets and incorporate sustainable practices into its operations. ODOT is updating its 2004 Sustainability Strategic Plan to include long- and short-term goals and strategies, as well as performance indicators to track agency progress. Sustainability concepts have been integrated into updates of the Oregon Transportation Plan and the State Bridge Repair Program, and an environmental management system has been developed to better manage materials used in maintenance activities.

Colorado DOT—CDOT is a member of Colorado's Transportation Environmental Resource Council, which consists of directors of transportation agencies and resource agencies from throughout the state. TERC has a sustainability subcommittee, which was created to learn from and coordinate the myriad of sustainability practices underway at Colorado agencies. The group is considering sustainability measures but has yet to select or implement them. CDOT also has a Greening Council, which is working to make the agency's activities greener. They define greening as "environmental responsible actions such as more efficient use of energy and water, recycling and reuse of materials, etc." The agency has done this to respond to its adopted "environmental ethic—the CDOT will support and enhance efforts to protect the environment and quality of life for all of Colorado's citizens in the pursuit of providing the best transportation systems and services possible."

New York State DOT—GreenLITES—NYSDOT established the GreenLITES Operations program to incorporate sustainability principles through its transportation maintenance, fleet administration, traffic, safety and mobility, and modal safety and security work. Under this program NYSDOT measures sustainability trade-offs through 100 separate tasks that are part of the planning process. These measures allow sustainability performance to be quantified and tracked in the operations and maintenance areas of the agency's activities. The program allows NYSDOT to distinguish agency areas by the extent to which they are incorporating sustainable projects and practices, internally monitor performance, recognize good practices, and communicate to the public.

Florida DOT—FDOT is making sustainability an integral consideration of its 2060 Transportation Plan under development, and in fact sustainability was one of the motivating factors for doing a 50-year instead of a 20-year plan. The agency has developed a definition of sustainability, but more specific goals, performance measures, etc. remain to be developed.

Metropolitan Planning Organizations

North Jersey Transportation Planning Authority—North Jersey Strategy Evaluation and Strategy Refinement—NJTPA's North Jersey Strategy Evaluation is used to capture how well the needs of the residents are being met by the regional transportation system. The outputs are then analyzed through a performance-based strategy refinement process. The potential refinement areas are screened to identify whether they are in line with NJTPA planning

principles. Among other criteria, the features of a refinement area must be "advancing sustainability by addressing energy and environmental issues."

California Partnership for the San Joaquin Valley—Governor Arnold Schwarzenegger established a partnership of MPOs in the San Joaquin Valley region to work together to address common issues and concerns. The partnership's Strategic Action Plan lays out a way for the region to lead California in sustainable growth and identifies ways to measure the progress. The partnership agreed upon a set of performance measures under each of the following categories: sustainable planning and growth; housing choices; transportation and mobility options; farming and agriculture; preservation of the environment; open space, air quality, and other natural resources; thriving economy/educational options; and cultural richness/unique attractions.

Metropolitan Transportation Commission—Sustainability Committee—The Metropolitan Transportation Commission, which is the regional planning organization for the San Francisco Bay Area, established a Sustainability Advisory Committee to look at how the agency is addressing sustainability concerns through its programs and policies. The committee found that MTC has many policies, programs, and projects that advance sustainability but is lacking in an overall definition and set of sustainability principles. The committee has put forth a set of recommendations, including adopting a formal definition of sustainable transportation, adopting a set of principles of sustainable transportation, carrying out a fuel use characterization study in the nine-county region, producing a report that highlights the MTC's role in advancing sustainable transportation systems, and implementing full cost accounting.

San Diego Association of Governments—SANDAG has developed a Sustainable Communities Strategy to illustrate the ways in which regional greenhouse gas (GHG) emission targets would be achieved through development patterns, infrastructure investments, and/or transportation measures or policies that are determined to be feasible. This effort will be consistent with the housing needs and address protection of sensitive resource areas, including areas under Habitat Conservation Plans.

Denver Regional Council of Governments—Through its regional comprehensive planning, DRCOG emphasizes sustainability in the region's vision for growth and development. In late 2008, DRCOG initiated a stakeholder involvement process to obtain input on the issue of sustainability for the Denver region. The objectives were to identify sustainability principles to incorporate into the Metro Vision Plan and identify performance measures. Stakeholders identified 30 sustainability principles that there was a general consensus to address. DRCOG was already addressing 11 of these, and six others were identified as being within DRCOG's scope. The DRCOG board has voted to move ahead with incorporating these into the regional Metro Vision Plan. DRCOG also hosts a webpage on regional sustainability.

The Chicago Metropolitan Agency for Planning—CMAP is currently developing its Go to 2040 Comprehensive Regional Plan, which promotes the integration of land use factors into its LRTP. The plan is based on the Regional Vision, which describes the region's desired future in terms of quality of life, natural environment, social systems, economy, and governance. It emphasizes the need to maximize existing physical infrastructure by encouraging reinvestment through mixed use, compact development, and infill redevelopment. It also highlights the need for safe communities, multimodal transportation systems, diversified economic centers, energy

efficiency, affordable housing, and civic involvement in the planning process. Sustainability, equity, and innovation are three important aspects involved in achieving all of these priorities.

CMAP is also part of the Regional Sustainability Working Group, which is developing a green transit plan for the Chicago metro region. The working group consists of transit agencies, the MPO, the city, the county, the DOT, and the city department of the environment. The group is funded through a grant from the Illinois DOT. The project began in October 2009 and has a goal of a final plan by October 2010. Although just getting started, the working group plans to look at fuel efficiency, other resources, and land use.

Mid-Ohio Regional Planning Commission—MORPC identifies sustainability directly in its mission: "The Mid-Ohio Regional Planning Commission (MORPC) will be the regional voice and a catalyst for sustainability and economic prosperity in order to secure a competitive advantage for central Ohio." MORPC's Center for Regional Development provides leadership and practical solutions to implement the land use and economic development policies that support the goal of a sustainable central Ohio. The focus of MORPC's 2009 State of the Region report is on sustainability.

Metropolitan Washington Council of Governments—MWCOG released a draft of its 2050 Vision Region Forward in October 2009. The vision establishes goals in the categories of land use, transportation, environmental, climate and energy, economic, housing, health and human services, education, and public safety. These goals are then connected through four categories, one of which is sustainability. The sustainability goals include a reduction in greenhouse gas emissions, efficient energy use, enhancement of established neighborhoods and preservation of land, and protection of air, water, and land resources. These goals are then supported by a set of targets and indicators.

Transit Agencies

Los Angeles Metropolitan Transit Authority (LMTA)—LMTA is integrating sustainable policies and initiatives in response to California's legislative efforts. The board has adopted the Metro Environmental Policy and is committed to using sustainable principles and practices in all planning, construction, operations, and procurement activities. All new construction greater than 10,000 square feet must incorporate LEED principles. The agency has developed a Metro Sustainability Plan, which outlines short-term and long-term projects, and helps track progress toward goals and commitments.

New York Metropolitan Transit Authority (MTA)—MTA serves as the umbrella/headquarters for the New York metro area transit agencies and knew that many transit agencies were involved in various greening activities. To coordinate these activities, they established the Blue Ribbon Commission to pull it all together. The commission is made up of people who have experience in the environmental realm and who represent a variety of interests from the private and public sectors, including those agencies that are partners in the report. Some of the recommendations are now being implemented (e.g., smart fleets), and others may be revised under the new administration.

Regional Transit Authority (Chicago, Illinois)—The Regional Transit Authority (RTA) is part of the Regional Sustainability Working Group, which is developing a green transit plan for the Chicago metro region. The working group consists of transit agencies, the MPO, the city, the county, the DOT, and the city department of the environment. The group is funded through a grant from the Illinois DOT. In collaboration with the Department of the Environment, the group plans to link this effort to the Chicago Climate Action Plan to ensure consistency. Although just getting started, the group plans to look at fuel efficiency, other resources, and land use. The final plan will include a set of performance measures and recommendations for how other agencies can help with the plan.

Hampton Roads Transit—HRT has a Go Green program. This includes activities as the headquarters to reduce waste and conserve energy, an energy reduction lighting program at the bus maintenance facility, and an Environmental Management System. The EMS has three targets:

- Prevent future releases from underground storage tanks.
- Reduce HRT's GHG/carbon emissions footprint.
- Reduce HRT's overall energy consumption.

HRT has an EMS team of representatives from different parts of the agency with different types of responsibilities to implement the program throughout. This team provides recommendations for senior-level staff to consider agency changes.

International Transportation Agencies

Transport for London—Transport for London manages the bus, underground, tram, and river service; a 580 km network of main roads; all of London's 4,600 traffic lights; and regulation of the taxi and private hire trade. It receives over 4 billion Pound Sterling in central government grant funding per year for major projects as well as fare receipts from over 3 billion public transport journeys each year. Transport for London was a founding signatory to the International Association of Public Transport's Charter on Sustainable Development.

Oslo Metropolitan Area—Since the 1990s, Oslo's government agencies with transportation and land use authority have been creating and implementing policies that have led to more sustainable mobility. These policies have been based upon the following principles: Public transportation should be the backbone of the urban pattern of development. The area should have a strong urban center with a concentration of workplaces, dwellings, shops, and cultural facilities; concentrated development of housing and workplaces close to public transit nodes; local communities with dense and variegated housing, green areas, and local facilities, with public transit and daily services within 500 m distance from the dwelling; a continuous green structure connecting the local communities with each other and with surrounding larger natural areas; and a main network of paths and roads for travel by bike. Major roads for motorized traffic should be led outside local communities and the city center, but the city center should still be accessible.

Transit New Zealand—Transit New Zealand, the agency responsible for national transportation, has developed an integrated approach toward performance-based planning and decision making that includes environmental performance measurements as an integral part.

Consistent performance measures are found in documents ranging from Transit New Zealand's corporate strategic plan to performance specifications in private service contracts.

United Kingdom (Highway and Rail)—In England, since 2001, Local Transport Authorities have been required to develop a five-year transport strategy (Local Transport Plan [LTP]) with a series of key performance indicators and to set targets to be achieved. The national government has provided a set of 198 indicators proposed as part of the New Performance Framework released in October 2007. The 198 indicators represent a set of national priorities, but it is acknowledged that there will be local priorities that authorities will also wish to set and assess. The U.K. highway agency is responsible for the construction, management, and maintenance of the motorway and main trunk road network in England (valued at ~$120billion). It has for some years had a Sustainable Development Action Plan, and it is notable in that it integrates its performance indicators with a whole organization approach to performance management. The U.K. Rail Industry developed a set of sustainable development indicators covering all three pillars of sustainability in 2007; it has conducted some benchmarking with other European Union countries and is now rolling this strategy out across the industry. The U.K. rail industry is highly fragmented (privatized and vertically segregated), yet the industry appears to have come together to tackle sustainability.

Sweden National Transportation Agencies—In Sweden the national transportation agencies have an obligation to report on progress for their share of the sustainable transportation targets of Sweden. Several years' worth of rather comprehensive monitoring and reporting exist.

Local Municipalities and Other Agency Types

New York City DOT—Sustainable Streets—The New York City DOT's Strategic Plan, released in 2008, lays out agency policies and practices to improve conditions of the city's population. The plan includes benchmarks in seven areas, one of which is greening. The greening actions address the areas of energy and resource consumption, recycled asphalt paving, and spill prevention.

New York City—PlaNYC—The Office of Long Term Planning and Sustainability (OLTPS) was formed to oversee the creation and implementation of PlaNYC, a broad blueprint devised to guide growth, investment, and environmental stewardship in New York City from 2007 (its inception) through 2030. PlaNYC tackles five key areas of concern: land, water, energy, transportation, and climate change. The plan was created in conjunction with the city agencies responsible for these areas, including:

- Land: City Planning, Parks, Housing Preservation and Development, and Environmental Protection.
- Water: Environmental Protection.
- Energy: Economic Development Corp, Department of City Administrative Services, and Sanitation.
- Transportation: City DOT and MTA (through board representation).
- Climate change: OLTPS and all implementing agencies.

PlaNYC defines sustainability for New York City as continued growth (up to 1 million new residents by 2030); preservation/maintenance of aging infrastructure (especially transportation,

water, and energy); continuing improvement of the environment, including contaminated lands, water, and air; and work to reduce the city's impact on global climate change (and simultaneously preparing to adapt to the consequences of climate change).

PlaNYC established over 125 goals/actions, most of which include a desired outcome (such as "reach a good state of repair on the city's roads and bridges"). Less consistently, PlaNYC specifies a performance target, such as "ensure that all New Yorkers live within 10 minutes of a park."

Alexandria, Virginia (Eco City Charter)—Alexandria's Environmental Action Plan 2030 (EAP) will serve as the road map for city leaders, staff, and citizens to implement the sustainability visions and principles set forth in Alexandria's Eco-City Charter (adopted by the city council on June 14, 2008). It explains how Alexandria can lead the new green economy, address the challenges of climate change, and continue its high quality of life while decreasing the city's carbon and ecological footprints. The EAP consolidates the sustainability efforts of all relevant city and regional agencies, and sets targets that they can work together to achieve. Alexandria's Environmental Coordination Group is currently working on establishing a strategy for measuring the performance of the plan's recommended activities.

CASE STUDY INTERVIEW GUIDE

Introduction and Consent Process for Interview Participants

The Texas Transportation Institute is conducting a research project titled "Sustainability Performance Measures for State DOTs and Other Transportation Agencies," sponsored by the National Cooperative Highway Research Program. As a part of this project, we are looking to document current transportation agency sustainability efforts in areas of strategic management, long-range planning and programming, project development and design, construction, and operations and maintenance, through interviews with staff involved with sustainability and performance measurement efforts.

An initial screening through literature reviews/Internet searches indicated that your agency would serve as a good case study. Would you be willing to participate in an interview regarding your agency's implementation of sustainability and performance measurement? The interview will take no longer than one hour. The information you provide will be incorporated into a project report detailing current practices and best practices among transportation agencies. Your participation will be confidential, and research records will be stored securely. Your name and job title will not be included in any publication resulting from this study.

If you have questions about the study, you may contact this study's principal investigator Joe Zietsman at (979) 458-3476 or Zietsman@tamu.edu. This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979) 458-4067 or irb@tamu.edu.

Are you willing to participate in this interview?

Interview Questions

1. How does your agency define sustainability?
2. In which of your agency's activities has sustainability been a consideration? Can you briefly describe what efforts have been undertaken in each area (e.g., conducted background research, established sustainability goals/objectives, or incorporated sustainability considerations in purchasing or contracting decisions)?
   a) Strategic management
   b) Long-range planning and programming
   c) Project development and design
   d) Construction
   e) Operations and maintenance
   f) Other: _____
3. How does your agency view the concept of sustainability? For example, is it one out of many impact areas to consider or a guiding principle?
4. What was the impetus to integrate sustainability into your agency's activities? For example, was there a push from leadership? Was the agency responding to public interest? Was it related to a specific area, like GHG emissions?
5. Have you established, or are you considering establishing, performance measures specifically related to sustainability? Through what process? What measures have you defined or considered? To what extent are these new measures versus existing measures already in use by the agency? Are these documented anywhere?
6. What data sources have you used for your sustainability measures? What challenges have you faced in identifying data for sustainability indicators?
7. Do you weight the relative importance of different sustainability metrics, e.g., in plan or project evaluation? If so, on what basis?
8. What process have you used for reporting the measures and using them in decision making? Do you think they have had any impacts on decision making?
9. What has been the stakeholder response to the measures (both internal [agency staff] and external [e.g., consultants, elected officials, or the public])? Have they found the measures measurable, meaningful, and easy to understand?
10. How would you rate your progress in implementation of sustainability principles? Of any associated performance measurement activities?
11. Can you share any lessons learned to date from the use of sustainability as a concept to direct and measure performance in your agency? To what extent have agency staff supported or bought into the concept?
12. Do you see your agency's consideration of sustainability evolving significantly in the future? If so, how?
13. Do you have any additional relevant documentation that we should look at?
14. Is there anyone else at your agency that we should talk to?

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APPENDIX D—DEFINING SUSTAINABLE TRANSPORTATION

OVERVIEW

Choosing or developing an explicit definition of "sustainability" or "sustainable transportation" is not essential for working with the framework developed in this research. It is recommended that sustainability be applied in transportation agencies by addressing universal sustainability principles, and translating them to appropriate goals, objectives, and performance measures. Some agencies may still want to develop a definition of sustainability for a variety of reasons, including ensuring buy-in from management, staff, or key stakeholders.

This section provides guidance for an agency to define sustainability for use in agency-wide initiatives. Each agency needs to define its own understanding, approach, and priorities with regard to sustainability, based on the principles of sustainability and the agency's specific concerns, needs, and contexts. Here, an agency's definition of sustainability is considered to encompass their understanding of what sustainability is as well as their intent in applying concepts of sustainability. Having an explicit definition of sustainability can potentially:

- Help an agency familiarize itself with and gain ownership of the concept of sustainability.
- Identify and pinpoint where its main concerns lie (e.g., urban or global environmental impacts).
- Communicate internally and externally about how sustainability is a priority to the agency.

However, there are also risks and downsides to an explicit definition of sustainability, which agencies must be aware of:

- A definition of sustainability can be abstract and of little use without further application.
- Sometimes an explicit definition may foster an illusion that transportation is a closed system that is sustainable in itself, while in fact it is strongly connected to other systems. This is especially true when agencies define sustainable transportation instead of sustainability.
- A short and simple definition may omit or suppress essential principles and aspects of sustainability for ease of communication.

Defining Sustainability in the Transportation Context

In the context of transportation and sustainability, Nijkamp et al. state: "There is no such thing as a generally accepted definition of 'sustainable transport', and it is doubtful whether one would—or could—ever exist" (*1*). This is partly due to scientific uncertainties, partly to ideological differences, and partly to conceptual problems involved in applying a general criterion like sustainability to a subsystem like transportation.

Despite these issues, the following guidance can help in developing a useful and relevant definition of sustainability. Basically, a definition should at a minimum:

- Take into account all of the basic principles of sustainability, while balancing and adapting them to the context.
- Consider that neither the transportation system nor the agency are closed systems.

- Consider the risk that simple definitions may be useless without further application.
- Use wording that promotes understanding as well as buy-in.

There are many approaches to developing a definition of sustainability, including to build a definition on theory, on existing definitions of sustainability or to develop an originally worded statement. Agencies can define sustainability with a "top-down" view (i.e., relating to conditions and impacts), or with a "bottom-up" approach (i.e., describing what a sustainable transportation system may look like). The definitions developed can be broad and comprehensive or more simple and streamlined. There are pros and cons to each approach to defining sustainability, and these are addressed through a critical review of selected definitions of sustainability provided in the next section. In this research, however, we propose a generally-applicable approach to defining sustainability that transportation agencies can easily implement. The approach is shown graphically in Figure D-1, followed by a description of the individual steps, and an example of how the guidance can be used to develop a definition of sustainability. The approach can also be used for an entity within an agency (such as a district, department, or division) to define sustainability as it relates to them.

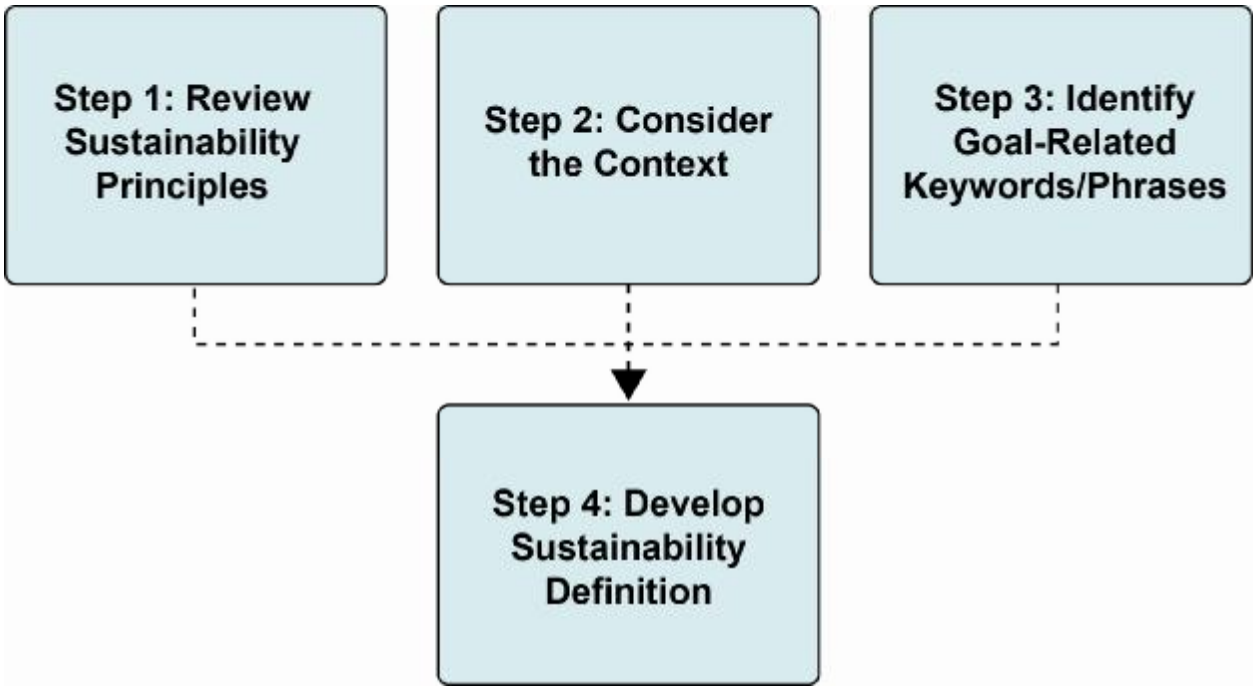

Figure D-1. Steps to Develop a Sustainability Definition.

Step 1—Review Sustainability Principles

Any definition of sustainability should be grounded in the basic principles of sustainability, which have been defined in this research as shown below.

Sustainability entails meeting human needs for the present and future, while:

- Preserving and restoring environmental and ecological systems.
- Fostering community health and vitality.
- Promoting economic development and prosperity.
- Ensuring equity between and among population groups and over generations.

While working all aspects of sustainability into a single definition may sometimes be difficult, it is recommended that elements from all four principles be reflected in the definition. In this first step, agencies should review and understand the basic principles of sustainability as a starting point to developing a definition.

Step 2—Consider the Context

The context in which sustainability is being considered is important in setting boundaries and context for the definition being developed. These considerations include:

- Function.
- Scope.
- Stakeholders.

Step 3—Identify Goal-Related Keywords/Phrases

Table D-1 shows the 11 goals for sustainability in transportation defined as part of the framework. These goals help define a set of keywords (also shown in Table D-1), which agencies can select from and incorporate based on their specific context, concerns, and priorities. The list of possible keywords is not meant to be exhaustive, but to provide an idea of issues that agencies may want to highlight in their definitions.

Table D-1. Transportation Sustainability Goals and Keywords/Phrases.

Transportation Sustainability Goals
1. **Safety**—Provide a safe transportation system for users and the general public. 2. **Basic Accessibility**—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs. 3. **Equity/Equal Mobility**—Provide options that allow affordable and equitable transportation opportunities for all sections of society. 4. **System Efficiency**—Ensure the transportation system's functionality and efficiency is maintained and enhanced. 5. **Security**—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards. 6. **Prosperity**—Ensure the transportation system's development and operation support economic development and prosperity. 7. **Economic Viability**—Ensure the economic feasibility of transportation investments over time. 8. **Ecosystems**—Protect and enhance environmental and ecological systems while developing and operating transportation systems. 9. **Waste Generation**—Reduce waste generated by transportation-related activities. 10. **Resource Consumption**—Reduce the use of non-renewable resources and promote the use of renewable replacements. 11. **Emissions and Air Quality**—Reduce transportation-related emissions of air pollutants and greenhouse gases.
Goal-Related Keywords/Phrases
• Safety • Accessibility • Options/equity • Efficiency • Security • Support for economic development • Feasibility • Reduce emissions • Affordability • Choices • Health • Trade • Environmental sensitivity • Efficient use of resources • Use of renewable resources

Step 4—Develop Sustainability Definition

Developing a definition of sustainability involves putting together the elements identified in Steps 1 through 3 into a statement that encapsulates the agency's understanding of what sustainability is, and the agency's intent in applying concepts of sustainability.

Example of Developing a Sustainability Definition

Agency Y is a small MPO serving an area of 60,000 people, focused mostly on multimodal transportation planning.

Step 1—Agency Y reviews the principles of sustainability to develop an understanding of the subject.

Step 2—Agency staff identified the following issues of relevance: a) small urban area, b) bus, bike, pedestrian facilities in addition to motor vehicles, c) focus on planning, d) include local stakeholders.

Step 3—The following were identified as goal-related keywords to be incorporated into the definition: accessibility, economic development, and the environment.

Step 4—The agency staff developed the following definition/statement:
"The Y area MPO pursues sustainability by providing a multimodal transportation system for all the citizens while working with local and regional stakeholders to promote accessibility for all, to support economic development, and to protect the environment for current and future generations."

Another example, developed for a design division within a hypothetical DOT, can be as follows:
"The design division supports DOT Z in moving towards sustainability by incorporating safety, economic feasibility and environmental considerations into our work, as we design long-lasting and quality projects."

Critical Review of Selected Sustainability Definitions

The previous section discussed the various approaches to developing definitions of sustainability in the transportation context. While no particular definition or approach is recommended in this research, it is useful to consider a range of definitions and understand the benefits and shortcomings of various approaches to define sustainability. This section presents a set of real and hypothetical example definitions, with a critical review and discussion of each.

Example 1—"Brundtland" Definition

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

This is the most well-known definition of sustainability, developed by the World Commission on Environment and Development in the Brundtland report (*2*). The definition is widely-accepted, but abstract. It emphasizes only the needs aspects, and the present and future dimensions. Numerous reports and articles have sought to give this definition more operational or technical specifications. It does not mention or address transportation.

Example 2—Brundtland Definition Applied to Transportation

> *"….sustainable transport is satisfying current transport needs without jeopardizing the ability of future generations to meet these needs"* (*3*).

This is perhaps the simplest existing formulation of sustainability in transportation. The definition is simple in the sense that it seems to apply the Brundtland concept directly to transportation. However, literally the definition only refers to *transportation* ('these') needs without mentioning environmental or social impacts. It is thereby further deprived of fundamental principles, even if those could be added in as 'transport needs.'

Example 3—Definition Based on Sustainability Principles

> *"Sustainability means meeting human needs for the present and future, while preserving environmental and ecological systems, improving quality of life, promoting economic development, and ensuring equity between and among population groups and over generations."*

This is an example of a more comprehensive, though abstract definition developed based on the principles defined in this research. This definition makes sure to address all key principles. It can help check for example if an assessment of a plan or a project is comprehensive from a sustainability point of view. It does not give any details about the terms used (for example, what it means to preserve environmental systems). Neither does it address transportation explicitly. 'Sustainability' could be replaced by 'sustainable transportation' but with the risk of alluding to transportation as an isolated system.

Example 4—Definition Based on Environmental/Ecological Research

> *"Sustainable systems and services are ones that can be perpetuated without dependence on exhaustible resources, without exploiting renewable resources beyond their rates of regeneration, without causing exceedences of limits to nature's ability to absorb and neutralize harmful pollutants."*

This example definition is constructed with inspiration from environmental research. This definition draws on environmental and ecological economics, by distinguishing between exploitation of three critical components, renewable resources, non-renewables and nature as sink for pollution; each component requiring a different management rule. The definition could then be detailed with goals for each type of resource, ecosystem etc. However, it obviously considers only the environmental dimension and its system side, ignoring issues like quality of life and economic development. It does not mention transportation, although as above, this could be added with the same remark attached.

Example 5—Definition by European Council of Transport Ministers

> *"A sustainable transport system is defined as one that:*
> - *allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations*
> - *is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development*
> - *limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise"* (*4*).

This example definition was adopted politically by the transport ministers of the European Union in 2001. The definition is quite comprehensive addressing both future, and present generations' needs, and the environmental, social, and economic dimensions, including equity. It is also

transportation specific (mobility here being more or less synonymous with transportation), highlighting a number of desirable features of transportation (affordability, safety, efficiency) as well as undesirable ones (resource use, emissions, land-use, noise). In this way it creates a broad overview of key concerns for the assessment of transportation from the sustainability point of view. However, it does not provide any distinction between critical and less essential concerns. The description of the limits of impacts is also not uniformly described. In some cases, limits are hinted at (e.g., the planet's ability to absorb emissions) while for others, no such information is provided (e.g., what is 'affordable'? what is a 'balanced regional development'?). The definition is essentially a rephrased checklist, and while comprehensive, is not well suited for quick communication. Still, it is very frequently cited in Europe and elsewhere (*5*).

Example 6—Definition by World Business Council of Sustainable Development

> *"Sustainable Mobility is the ability to meet society's need to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future."* (*6*).

This is a streamlined definition of 'Sustainable Mobility,' which has been used by the World Business Council of Sustainable Development (WBCSD). This definition differs from previously described ones in that it emphasizes the positive contributions of transportation, with the negative impacts vaguely mentioned as conditions that should not be sacrificed to the extent that they are essential. It has low explicitness with regard to environmental and equity principles. This limitation seems to be recognized by the WBCSD, as they proceed to supplement the definition with indicators for a range of environmental impacts.

Example 7—Modified WBCSD Definition 1

> *"Sustainability in transportation is the fulfillment of present transportation needs for accessibility, mobility, connectivity, safety, security and trade without undermining the possibilities to fulfill social, economic or environmental needs in an equitable way, today or in the future."*

This is a modified version of the previous WBCSD definition, which is more explicit with regard to positive functions of transportation rather than the negative ones. However, the negative impacts are more strongly emphasized than in the previous definition by the WBCSD.

Example 8—Modified WBCSD Definition 2

> *"Sustainable transportation is seen as transportation that meets mobility needs, while also preserving and enhancing human and ecosystem health, economic progress and social justice for now and for the future"*(*7*).

This definition is a further modification that collapses the transportation functions back into to mobility needs. Rather than contrasting with negative impacts, transportation is seen as a potentially positive contributor to human health, social justice, etc. in this definition.

Example 9—Modified WBCSD Definition 3

> *"Sustainability means meeting the imperatives of environmental protection whilst at the same time taking account of the need for access."* (*8*).

This is a highly condensed definition that emphasizes access as the ultimate goal rather than transportation or mobility. This concept highlights the importance of considering 'what to sustain'? Is it transportation (i.e., flows, movements), is it mobility (i.e., capacity or potential to move), or is it the ultimate aim with the movement (i.e., to gain access to places, services, jobs, markets, etc.)? Another source thus chose to define sustainable accessibility as the main aim, meaning "….accessibility with as little as possible use of non renewable, or difficult to renew, resources, including land and infrastructure" (*9*). A problem in these cases is to define and measure access operationally; this may be less critical in cases where the goal is instead defined as transportation.

Example 10—Bottom-Up Approach

> *"Sustainable transportation is transportation by non-motorized modes, or by efficiently utilized motorized public transport modes, or by fully occupied cars or trucks running on renewable energy sources, and fulfilling the most advanced environmental and safety performance criteria."*

The previously presented definitions share a reliance on top-down principles and descriptions of conditions and impacts. They do not address transportation systems directly from the bottom-up, for example by defining what a sustainable transportation system looks like, or which ones would be sustainable and which ones not. The above is a hypothetical example of a definition taking the bottom-up approach. Such a definition would be radical, as much of current (and future) transportation would be deemed unsustainable by default. More dubious, is that the criteria as formulated would be arbitrary, as it is not clear for example if public transport is always better than cars with regard to all principles of sustainable development (for example quality of life), if renewable resources are always a benefit for the environment, or if the most advanced standards today are actually sufficient to ensure long-term sustainability. The constructed definition is included here to alert to such risks inherent in the bottom-up approach, as when talking about more sustainable modes. This does not mean that agencies should not state such priorities if it so desired. It is, however, important that the sustainability of particular modes, should not necessarily be assumed, but rather considered contingent on the operational application of top-down principles.

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APPENDIX E—PERFORMANCE MEASURES COMPENDIUM

Note: Italicized entries are featured as examples in Appendix D.

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
1.1	**Reduce the number and severity of crashes**	*Change in the number and severity of crashes*	Change in the number of crashes by crash type and contributing factor	Change in the number and severity of truck crashes		
1.2	**Ensure safety considerations are addressed for all modes**	Change in the number and severity of crashes by user type (e.g., pedestrian, bicycle, transit user, freight)	Change in the number of grade crossing collisions/incidents			
1.3	**Ensure safety is considered early in project planning**	Change in percentage of projects where safety of a project was reviewed in each of the project development stages by a multidisciplinary review team	Change in the percentage of projects implementing predictive methods of the *AASHTO Highway Safety Manual*			
1.4	**Ensure projects consider the 4Es (engineering, education, enforcement, EMS) of safety**	Change in the percentage of projects where non-infrastructure based safety countermeasures were selected as part of the project	Number of projects incorporating the use of innovative TSM and ITS solutions that address human factors considerations			
1.5	**Plan road networks that are predictable and recognizable**	Existence of a functional class system of highways	Existence of a system that adjust speeds based on the presence of alternative modes and context			

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 2: Programming						
1.6	**Develop programs that maximize return on safety investment**	Change in return on investment (reduction in the number and severity of crashes for the expenditure)	Change in the number and proportion of projects evaluated on substantive safety versus nominal safety			
1.7	**Develop a performance based safety improvement program**	Number and proportion of projects evaluated for impact on crashes	Number and cost of projects that address safety concerns at the system, corridor, and local levels			
1.8	**Prioritize projects with explicit safety considerations**	*Change in number of programmed projects with highest reduction in crashes out of all alternatives*				

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
1.9	**Develop projects that meet maximum safety requirements**	Return on investment for individual project (reduction in the number and severity of crashes for the expenditure)	Project is evaluated on substantive safety versus nominal safety			
1.10	**Apply a performance based safety improvement program**	Project is evaluated for impact on crashes	Project addresses safety concerns at the system, corridor, and local levels (as relevant)			
1.11	**Develop projects with explicit safety considerations**	*Selected project has highest reduction in crashes out of all alternatives*				

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
1.12	**Reduce crash risk in work zones**	*Change in number of crashes per time unit within a particular work zone*	Change in number of crashes as a portion of total time of work zones by functional class, county, and district/region - where possible, distinguish between active and passive work zone time periods	Change in number and severity of work zone truck crashes		
1.13	**Reduce the risk of construction and maintenance personnel working in work zones along roadways**	Change in number of crashes involving one or more construction and maintenance personnel and/or vehicles per time unit that the work zone exists	Number of construction and maintenance personnel killed at work zones by functional class, county, and district/region	Number of construction and maintenance personnel injured at work zones by functional class, county, and district/region	Change in the number of grade crossing collisions/incidents due to new construction (removal of grade crossing)	
1.14	**Provide improved work zone Traffic Control Activities**	Change in the number of traffic control supervisors that are trained and on site	Change in the number of traveler safety complaints annually	Change in the number of workers injured during the course of traffic control activities	Change in the percentage of construction or maintenance projects that use traveler information systems to provide public information on alternative routes and modes during construction or maintenance	
1.15	**Maintain safe facilities**	Change in time duration to correct potential roadway safety concerns that requires construction and/or maintenance action	Change in the time taken to carry out repairs to roadside safety hardware (by category, i.e., guardrail, guardrail end-treatment, cable barrier, cable barrier end treatment, etc.)	Change in the percentage of construction and maintenance projects providing accessible routes during construction and maintenance (where applicable)		

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 5: Maintenance						
1.16	**Reduce crash risk in work zones**	*Change in number of crashes per time unit within a particular work zone*	Change in number of crashes as a portion of total time of work zones by functional class, county, and district/region—where possible, distinguish between active and passive work zone time periods	Change in number and severity of work zone truck crashes		
1.17	**Reduce the risk of construction and maintenance personnel working in work zones along roadways**	Change in number of crashes involving one or more construction and maintenance personnel and/or vehicles per time unit that the work zone exists	Number of construction and maintenance personnel killed at work zones by functional class, county, and district/region	Number of construction and maintenance personnel injured at work zones by functional class, county, and district/region	Change in the number of grade crossing collisions/incidents due to new construction (removal of grade crossing)	
1.18	**Provide improved Work zone Traffic Control Activities**	Change in the number of traffic control supervisors that are trained and on site	Change in the number of traveler safety complaints annually	Change in the number of workers injured during the course of traffic control activities	Change in the percentage of construction or maintenance projects that use traveler information systems to provide public information on alternative routes and modes during construction	
1.19	**Maintain safe facilities**	Change in time duration to correct potential roadway safety concerns that requires construction and/or maintenance action	Change in the time taken to carry out repairs to roadside safety hardware (by category, i.e., guardrail, guardrail end-treatment, cable barrier, cable barrier end treatment, etc.)	Change in the percentage of scheduled maintenance safety activities delivered on time	Change in the percentage of construction and maintenance projects providing accessible routes during construction and maintenance (where applicable)	

Goal 1. Safety—Provide a safe transportation system for users and the general public.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
1.20	**Reduce crash risk on two-lane rural highways**	Change in number of crashes by crash type on two-lane rural highways	Change in number and severity of truck crashes in a corridor/segment due to operational improvements	Change in the number of grade crossing collisions/incidents due to operational improvements (e.g., traffic control and warning devices)		
1.21	**Reduce the crash risk of the traveling public using transit**	Change in transit crashes as a proportion of total crashes on the highway network	*Number of fatal and disabling injuries sustained by transit users as a portion of 100 million passenger miles travelled or of 100,000 riders*			
1.22	**Reduce the crash risk of vulnerable road users**	Change in the total number of pedestrian and bicyclist crashes; and fatal and disabling crashes by 100,000 population	Change in the percentage of signal systems with active ped devices (e.g., crosswalks, signals, meeting ADA standards)			
1.23	**Reduce the risk of the traveling public on freeways during incidents**	Change in the total time taken to clear an incident scene (e.g., crash, hazardous material spill, etc.) from the time of the incident	Change in the total number and severity of secondary crashes (crashes occurring as a result of queuing or disruptions in traffic flow as a result of an incident)			
1.24	**Reduce crashes related to intersection and ramp operations**	Change in the percentage of signals coordinated along each major arterial	Change in the percentage of expressway/freeway ramps metered in a corridor where severe congestion exists			
1.25	**Reduce crashes related to network operations**	Change in the percentage of signs meeting retroreflectivity criteria	Change in the percentage of edge lines meeting retroreflectivity criteria	Change in the percentage of system meeting curve warning, speed, and signing criteria	Change in the percentage of intersections providing turn pockets and associated protected left-turn phasing when warranted	Change in the percentage of system providing accessible routes

Goal 2. Basic Accessibility—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
2.1	**Ensure accessibility to jobs**	*Change in the number of jobs within reasonable travel time (by mode) for region's population*	Change in jobs/housing balance			
2.2	**Ensure accessibility to essential destinations**	Change in travel time (by mode) to schools, health services, grocery stores, civic and public spaces, recreation	Change in travel time of goods to essential markets (region wide)	Change in number of enterprises in key industries with reasonable access to high capacity highway or rail facilities		

Goal 2. Basic Accessibility—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 2: Programming						
2.3	**Program projects that increase access to job opportunities**	Change in the number of jobs within reasonable travel time (by mode) for region's population due to project				
2.4	**Program projects that increase access to essential destinations**	*Change in travel time (by mode) to schools, health services, grocery stores, civic and public spaces, recreation due to project*	Change in travel time of goods to essential markets due to project	Change in number of enterprises in key industries with reasonable access to high capacity highway or rail facilities due to project		

Goal 2. Basic Accessibility—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 3: Project Development						
2.5	**Develop projects that increase access to job opportunities**	Change in the number of jobs within reasonable travel time (by mode) for region's population due to selected project alternative				
2.6	**Develop projects that increase access to essential destinations**	*Change in travel time (by mode) to schools, health services, grocery stores, civic and public spaces, recreation due to selected project alternative*	Change in travel time of goods to essential markets due to selected project alternative	Change in number of enterprises in key industries with reasonable access to high capacity highway or rail facilities due to selected project alternative		

Goal 2. Accessibility—Provide a transportation system that offers adequate accessibility that allows people to meet at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 4: Construction						
2.7	**Reduce delay to commuters due to construction activities**	*Change in travel time delay for commuters due to construction activities*				
2.8	**Minimize travel time delay (by mode) for affected population due to construction**	Change in travel time delay (by mode) for affected population due to construction activities	Change in travel time of goods to essential markets due to construction activities			

Goal 2. Basic Accessibility—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 5: Maintenance						
2.9	**Reduce delay to commuters due to maintenance activities**	*Change in travel time delay for commuters due to maintenance activities*				
2.10	**Minimize travel time delay (by mode) for affected population due to maintenance activities**	Change in travel time delay (by mode) for affected population due to maintenance activities	Change in travel time of goods to essential markets due to maintenance activities			

Goal 2. Basic Accessibility—Provide a transportation system that offers accessibility that allows people to fulfill at least their basic needs.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 6: System Operations						
2.11	**Reduce travel time to jobs and other essential destinations through operational improvements**	Change in travel time per mode per destination type				
2.12	**Improve travel time reliability to jobs and other essential destinations through operational improvements**	*Change in the reliability of travel time per mode per destination type*	Change in travel time of goods to essential markets due to operational improvements			

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
3.1	**Ensure comparable transportation system performance for all communities**	Change in LOS for disadvantaged and non-disadvantaged neighborhoods				
3.2	**Ensure reasonable transportation options for all communities**	Relative change in the percentage of disadvantaged population with convenient access to high quality transit service	Relative change in the percentage of streets with sidewalks or walking paths within a community			
3.3	**Ensure accessibility to jobs and essential destinations for all communities**	*Relative change in the level of access for disadvantaged populations to jobs, schools, health services, grocery stores, civic and public spaces, recreation*				
3.4	**Ensure affordable transportation for all communities**	Relative change in the transportation cost index				
3.5	**Ensure that competitive options for freight movements exist for all communities**	Relative change in freight investment servicing disadvantaged populations				

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
3.6	**Program transportation projects that improve transportation infrastructure equitably**	*Change in ratio of transportation disadvantaged to non-disadvantaged population benefitting from program*	Ratio of disadvantaged to non-disadvantaged population experiencing negative impacts of transportation program (e.g., noise, air quality, neighborhood fragmentation)			
3.7	**Program projects that improve transportation options equitably**	All modes (automobile, transit, pedestrian, bicycle) accommodated or improved by program				
3.8	**Program projects that improve accessibility equitably**	Ratio of disadvantaged to non-disadvantaged people with increased accessibility due to program				
3.9	**Program projects that reduce transportation costs for low-income communities**	Relative change in the transportation cost index due to program				
3.10	**Program projects that increase competitive options for freight movements in all communities**	Change in ratio of transportation disadvantaged to non-disadvantaged population benefitting from freight program				

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
3.11	**Develop transportation projects that improve transportation infrastructure equitably**	Change in ratio of transportation disadvantaged to non-disadvantaged population benefitting from project	*Ratio of disadvantaged to non-disadvantaged population experiencing negative impacts of transportation project (e.g., noise, air quality, neighborhood fragmentation)*			
3.12	**Develop projects that improve transportation options equitably**	All modes (automobile, transit, pedestrian, bicycle) accommodated or improved by project				
3.13	**Develop projects that improve accessibility equitably**	Ratio of disadvantaged to non-disadvantaged people with increased accessibility due to project				
3.14	**Develop projects that reduce transportation costs for low-income communities**	Relative change in the transportation cost index due to project				
3.15	**Develop projects that increase competitive options for freight movements in all communities**	Change in ratio of transportation disadvantaged to non-disadvantaged population benefitting from freight project				

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 4: Construction						
3.16	**Reduce delay due to construction activities equitably**	*Ratio of disadvantaged to non-disadvantaged system users experiencing delay due to construction activities*				
3.17	**Maintain or improve transportation options during construction for all communities**	Ratio of disadvantaged to non-disadvantaged system users experiencing fewer transportation options due to construction activities				

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 5: Maintenance						
3.18	**Reduce delay due to maintenance activities equitably**	*Ratio of disadvantaged to non-disadvantaged system users experiencing delay due to maintenance activities*				
3.19	**Maintain or improve transportation options during maintenance for all communities**	Ratio of disadvantaged to non-disadvantaged system users experiencing fewer transportation options due to maintenance activities				

Goal 3. Equity/Equal Mobility—Provide options that allow affordable and equitable transportation opportunities for all sections of society.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 6: System Operations						
3.20	**Reduce travel time to jobs and essential destinations through operational improvements equitably and across all modes**	Ratio of disadvantaged to non-disadvantaged system users experiencing reduced travel time due to operational improvements				
3.21	**Improve reliability in travel time to jobs and other essential destinations through operational improvements equitably and across all modes**	Ratio of disadvantaged to non-disadvantaged system users experiencing improved reliability of travel time by mode and destination type				
3.22	**Ensure that transportation costs do not disproportionately impact low-income users**	*Change in incidence of travel costs by income group due to operational improvements*				
3.23	**Increase competitive options for freight movements in all communities through operational improvements**	Relative change in operational investment by freight mode servicing disadvantaged communities				

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
4.1	**Ensure that the transportation system is functional for all users**	Change in volume/capacity ratio by functional class	Change in multimodal LOS (using HCM measures)	Change in LOS on key freight routes OR truck v/c ratio		
4.2	**Ensure that the existing transportation system achieves and maintains a state of good repair**	Change in percentage of roadway/transit infrastructure achieving state of good repair				
4.3	**Ensure that transportation options are efficient for all users**	*Change in travel time index (TTI) by mode*	Change in person hours of recurring delay, by mode			
4.4	**Ensure that reliable transportation options are maintained for all users**	Change in person hours of non-recurring delay, by mode	Change in buffer time (by mode and freight)	Relative change in hours of non-recurring delay on key freight corridors and approach network		

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
4.5	**Program projects that maintain or improve the functionality of the transportation system for all users**	Change in volume/capacity ratio [congestion reduction per unit (lane-mile)] due to program	Change in multimodal LOS due to program	Change in LOS on key freight routes OR truck v/c ratio due to program		
4.6	**Program projects designed to maintain or achieve a state of good repair for the existing transportation system**	*Change in existing (lane miles, track miles, sidewalk miles) in a state of good repair due to program*				
4.7	**Program projects that maintain or improve the efficiency of the transportation system for all users**	Change in TTI (by mode if applicable) due to program	Change in person hours of recurring delay, by mode, due to program			
4.8	**Develop programs that maintain or improve the reliability of the transportation system for all users**	Change in person hours of non-recurring delay due to program	Change in buffer time due to program	Relative change in hours of non-recurring delay on key freight corridors and approach network due to program		

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
4.9	**Develop projects that maintain or improve the functionality of the transportation system for all users**	*Change in volume/capacity ratio [congestion reduction per unit (lane-mile)] due to project*	Change in multimodal LOS due to project	Change in LOS on key freight routes OR truck v/c ratio due to project		
4.10	**Develop projects designed to maintain or achieve a state of good repair for the existing transportation system**	Change in existing (lane miles, track miles, sidewalk miles) in a state of good repair due to project				
4.11	**Develop projects that maintain or improve the efficiency of the transportation system for all users**	Change in TTI (by mode if applicable) due to project	Change in person hours of recurring delay, by mode, due to project			
4.12	**Develop projects that maintain or improve the reliability of the transportation system for all users**	Change in person hours of non-recurring delay due to project	Change in buffer time due to project	Relative change in hours of non-recurring delay on key freight corridors and approach network due to project		

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
4.13	**Maintain the functionality of the transportation system during construction activities**	Change in peak hour persons moved due to construction activities	Change in multimodal LOS due to construction activities	Change in LOS on key freight routes OR truck v/c ratio due to construction activities		
4.14	**Minimize the impact of construction activities on system efficiency**	*Change in travel time delay for commuters due to construction activities*	Change in person hours of recurring delay due to construction activities			
4.15	**Minimize the impact of construction activities on system reliability**	Change in person hours of non-recurring delay due to construction activities	Change in buffer time due to construction activity	Relative change in hours of non-recurring delay on key freight corridors and approach network due to construction		

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 5: Maintenance						
4.16	**Maintain the functionality of the transportation system during maintenance activities**	Change in peak hour persons moved due to maintenance activities	Change in LOS due to maintenance activities	Change in LOS on key freight routes OR truck v/c ratio due to maintenance activities		
4.17	**Conduct maintenance activities with sufficient frequency to maintain the state of good repair**	Change in existing (lane miles, track miles, sidewalk miles) in a state of good repair due to maintenance activities				
4.18	**Minimize the impact of maintenance activities on system efficiency**	*Change in travel time delay for commuters due to maintenance activities*	Change in person hours of recurring delay due to maintenance activities			
4.19	**Minimize the impact of maintenance activities on system reliability**	Change in person hours of non-recurring delay due to maintenance activities	Change in buffer time due to maintenance activity	Relative change in hours of non-recurring delay on key freight corridors and approach network due to maintenance activities		

Goal 4. System Efficiency—Ensure the transportation system's functionality and efficiency is maintained and enhanced.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
4.20	**Implement operational improvements that maintain system functionality**	Change in peak hour persons moved due to operational improvements	Change in LOS due to operational improvements	Change in LOS on key freight routes OR truck v/c ratio due to operational improvements		
4.21	**Implement operational improvements that minimize the deterioration of transportation infrastructure and assets**	Change in useful life of infrastructure due to operational improvements				
4.22	**Implement operational improvements that enhance or maintain the efficiency of transportation options**	Change in TTI due to operational improvements	Change in person hours of recurring delay due to operational improvements			
4.23	**Implement operational improvements that enhance or maintain the reliability of transportation options**	*Change in person hours of non-recurring delay due to operational improvements*	Change in buffer time due to operational improvements	Relative change in hours of non-recurring delay on key freight corridors and approach network due to operational improvements/issues		

Goal 5. Security—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning						
5.1	**Prevent incidents within a transportation agency's control and responsibility**	Change in level of redundancy for critical passenger and freight infrastructure				
5.2	**Protect transportation users, agency personnel, and critical infrastructure**	*Change in share of agency staff that have received appropriate emergency training*				
5.3	**Improve the capacity of the transportation system to recover swiftly from incidents**	Change in the capacity of parallel/redundant routes across all modes				
5.4	**Enhance the security of freight transportation assets (e.g., ports)**	Change in the capacity of parallel/redundant routes along major freight corridors	Relative change in funding allocated to disaster/incident response and management			

Goal 5. Security—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
5.5	**Program projects that prevent incidents within a transportation agency's control and responsibility**	*Change in level of redundancy for critical passenger and freight infrastructure*				
5.6	**Program projects that protect transportation users, agency personnel, and critical infrastructure**	Change in the number/value of projects as part of program designed to protect transportation users, agency personnel, and critical infrastructure				
5.7	**Program projects that improve the capacity of the transportation system to recover swiftly from incidents**	Change in the number/value of projects as part of program designed to improve capacity of the transportation system to recover swiftly from incidents				
5.8	**Program projects that enhance the security of freight transportation assets (e.g., ports)**	Change in the number/value of projects as part of program designed to enhance the security of freight transportation assets (e.g., ports)				

Goal 5. Security—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
5.9	**Develop projects that prevent incidents within a transportation agency's control and responsibility**	*Change in level of redundancy for critical passenger and freight infrastructure*				
5.10	**Develop projects that protect transportation users, agency personnel, and critical infrastructure**	Change in the number/value of projects designed to protect transportation users, agency personnel, and critical infrastructure				
5.11	**Develop projects that improve the capacity of the transportation system to recover swiftly from incidents**	Change in the number/value of projects designed to improve capacity of the transportation system to recover swiftly from incidents				
5.12	**Develop projects that enhance the security of freight transportation assets (e.g., ports)**	Change in the number/value of projects designed to enhance the security of freight transportation assets (e.g., ports)				

Goal 5. Security—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
	N/A	N/A				
Focus Area 5: Maintenance						
	N/A	N/A				

Goal 5. Security—Ensure the transportation system is secure from, ready for, and resilient to threats from all hazards.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
5.13	**Prevent incidents within a transportation agency's control and responsibility**	Change in level of redundancy for critical passenger and freight infrastructure	Annual number of incidents			
5.14	**Protect transportation users, agency personnel, and critical infrastructure**	Change in the share of agency staff that have received appropriate emergency training				
5.15	**Support regional, state, and local emergency responders with resources including facilities, equipment, and personnel**	Relative change in capital funding allocated to disaster/incident response and management				
5.16	**Help the transportation system recover swiftly from incidents**	Incident clearance time for selected incidents				
5.17	**Implement operational improvements that enhance the security of freight transportation assets (e.g., ports)**	*Relative change in operational funding allocated to disaster/incident response and management*				

Goal 6. Prosperity—Ensure the transportation system's development and operation support economic development and prosperity.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
6.1	**Support growth in jobs and income by improving travel efficiency/reducing congestion**	Change in average truck speed on major freight corridors	*Change in travel delay (e.g., travel time index) at major freight bottlenecks by mode*	Change in corridor/city/commuter-shed-specific travel delay or other congestion-related measure	Change in cost of goods movement in key national modal corridors	
6.2	**Support growth in jobs and income by improving access to markets and factors of production (labor and raw materials)**	Change in population within user-defined distance to four-lane highway facilities; air cargo service; scheduled air service; intercity bus service; intercity rail service, etc.	Change in access to jobs and labor (How many jobs and how much labor can be accessed within various periods of time for an entire region or smaller areas)	Change in regional and shortline trackage with 286,000 lb rating		
6.3	**Support growth in jobs and income**	Net change in jobs/income associated with transportation plan implementation				

Goal 6. Prosperity—Ensure the transportation system's development and operation support economic development and prosperity.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 2: Programming						
6.4	**Support growth in jobs and income by improving travel efficiency/reducing congestion through programming**	Change in average truck speed on major freight corridors due to program	Change in travel delay (e.g., travel time index) at major freight bottlenecks by mode due to program	Change in corridor/city/commuter-shed-specific travel delay or other congestion-related measure due to program	Change in cost of goods movement in key national modal corridors due to program	Net change in jobs/income due to program
6.5	**Support growth in jobs and income by improving access to markets and factors of production (labor and raw materials) through programming**	Change in population within user-defined proximity to access controlled four-lane highway facilities; air cargo service; scheduled air service; intercity bus service; intercity rail service, etc. due to program	*Change in access to jobs and labor (How many jobs and how much labor can be accessed within various periods of time for an entire region or smaller areas) due to program*	Change in regional and shortline trackage with 286,000 lb rating due to program		
6.6	**Program projects that reduce freight transportation costs**	Change in cost of shipment per ton/mile, by mode due to program	Existence of a process for considering the freight specific benefits and costs in the programming phase			

Goal 6. Prosperity—Ensure the transportation system's development and operation support economic development and prosperity.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 3: Project Development						
6.7	**Develop projects that support growth in jobs and income by improving travel efficiency/reducing congestion**	Change in average truck speed on major freight corridors due to project	Change in travel delay (e.g., travel time index) at major freight bottlenecks by mode due to project	Change in corridor/city/commuter-shed-specific travel delay or other congestion-related measure due to project	Change in cost of goods movement in key national modal corridors due to project	Net change in jobs/income due to project
6.8	**Develop projects that support growth in jobs and income by improving access to markets and factors of production (labor and raw materials)**	*Change in population within user-defined proximity to access controlled four-lane highway facilities; air cargo service; scheduled air service; intercity bus service; intercity rail service, etc. due to project*	Change in access to jobs and labor (How many jobs and how much labor can be accessed within various periods of time for an entire region or smaller areas) due to project	Change in regional and shortline trackage with 286,000 lb rating due to project		
6.9	**Develop projects that reduce freight transportation costs**	Change in cost of shipment per ton/mile, by mode due to project	Existence of a process for considering the freight specific benefits and costs in the programming phase due to project			

Goal 6. Prosperity—Ensure the transportation system's development and operation support economic development and prosperity.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 4: Construction						
	N/A	NA				
Focus Area 5: Maintenance						
	N/A	NA				

Goal 6. Prosperity—Ensure the transportation system's development and operation support economic development and prosperity.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 6: System Operations						
6.10	**Support growth in jobs and income by improving travel efficiency/reducing congestion**	Change in average truck speed on major freight corridors	Change in travel delay (e.g., travel time index) at major freight bottlenecks by mode	*Change in corridor/city/commuter-shed-specific travel delay or other congestion-related measure*	Change in cost of goods movement in key national modal corridors	
6.11	**Support growth in jobs and income by improving access to markets and factors of production (labor and raw materials)**	Change in population within user-defined proximity to access controlled four-lane highway facilities; air cargo service; scheduled air service; intercity bus service; intercity rail service, etc.	Change in access to jobs and labor (How many jobs and how much labor can be accessed within various periods of time for an entire region or smaller areas)	Change in regional and shortline trackage with 286,000 lb rating		

Goal 7. Economic Viability—Ensure the economic feasibility of transportation investments over time.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning						
7.1	**Ensure the expected value of social and economic benefits created by proposed transportation projects exceeds their costs**	Project-level cost/benefit ratio for proposed alternatives/policies, including freight				
7.2	**Ensure the selection of the lowest cost project alternative**	Proportion of projects subjected to LCCA				
7.3	**Ensure that revenue sources used to pay for transportation infrastructure are sufficient to meet expected needs**	Percent of annual transportation funding needs that can be met with annual revenues				
7.4	**Ensure that the financial burden borne by transportation system users is shared equitably**	*Cost per user/vehicle/household of taxes and fees dedicated to transportation*				

Goal 7. Economic Viability—Ensure the economic feasibility of transportation investments over time.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
7.5	**Ensure the expected value of social and economic benefits created by proposed transportation programs exceeds their costs**	*Project-level cost/benefit ratio for proposed programs, including freight*				
Focus Area 3: Project Development						
7.6	**Ensure the expected value of social and economic benefits created by major transportation projects exceeds their costs**	*Project-level cost/benefit ratio for proposed projects and/or programs, including freight*				
7.7	**Ensure the selection of the lowest cost project alternative**	Proportion of projects for which LCCA is verified/updated through post project review				

Goal 7. Economic Viability—Ensure the economic feasibility of transportation investments over time.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
7.8	**Ensure construction costs are within planned budget**	*Proportion of projects with construction costs within planned budget*				
Focus Area 5: Maintenance						
7.9	**Ensure maintenance costs are within planned budget**	*Proportion of projects with maintenance costs within planned budget*				
Focus Area 6: System Operations						
7.10	**Ensure operations costs are within planned budget**	*Proportion of projects with operations costs within planned budget*				

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 1: Planning						
8.1	**Ensure properly functioning environmental and ecological systems**	Change in the number of formalized working partnerships (e.g., MOUs) with public and private environmental stakeholders	Change in the number of programmatic environmental permits and approvals for streamlining stakeholder regulatory review and support	Preparation of an annual Sustainability Report on ecological trends and ecological performance against agency sustainability policies and goals	Change in the percentage of transportation system covered by consistent and accessible Regional Ecosystem Framework(s) or spatially-related ecological database(s)	
8.2	**Ensure that environmental and ecological systems are free of contaminants and pollutants**	*Existence of an agency-wide Environmental Management System (i.e., plan documenting environmental policy, environmental objectives and targets, identified regulatory requirements and compliance with requirements, defined roles and responsibilities, employee training plan, listing of documented processes, preventive actions, corrective actions, and emergency procedures [i.e., ISO 14001])*				

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
8.3	**Program projects that maximize ecological opportunities and ecosystem benefits**	*Change in the percentage of projects programmed on the basis of achieving priority ecological outcomes*				
8.4	**Maintain ecosystem functions and processes**	Change in the number of projects programmed consistent with Regional Ecosystem Framework(s)	Change in percentage of projects evaluated for ecological impacts through an informed decision-making (comprehensive environmental review) process			
8.5	**Maintain enterprise-wide habitat connectivity**	Change in road miles/square miles of watershed due to program	Change in number of fish passage barriers/hydrological obstructions in right-of-way due to program	Change in the number of retrofitted/maintained drainage and crossing structures due to program		
8.6	**Program projects that maintain and improve quantity and quality of water and aquatic ecosystems**	Change in number [percentage] of projects programmed to maintain or improve water quantity or quality				
8.7	**Program projects that allow normal physical processes within the stream-floodplain corridor**	Change in the number of new and retrofitted water crossings other than overflow crossings that: (1) promote natural sediment transport patterns for the reach, (2) provide unaltered fluvial debris movement, and (3) allow for longitudinal continuity and connectivity of the stream-floodplain system due to program	Change in the number of new and retrofitted water crossings that allow lateral connectivity between the stream and floodplain due to program			
8.8	**Program projects that are free of contaminants and pollutants**	Change in the percentage of projects covered by a documented Environmental Management System due to program	Change in the number of projects developed for remediation of contaminated sites due to program			

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 3: Project Development						
8.9	**Develop projects that maximize ecological opportunities and ecosystem benefits**	Change in the percentage of project alternatives selected on the basis of achieving priority ecological outcomes				
8.10	**Maintain ecosystem functions and processes**	Change in the number of projects designed consistent with Regional Ecosystem Framework(s)				
8.11	**Conserve natural resources/capital during project implementation**	Change in ratio of resource replacement mitigation (e.g., wetland restoration, creation, enhancement, and preservation) to resource impact (area or function) by habitat type due to project	Change in net area of undeveloped land converted to transportation uses (acres) due to project	Change in percentage of projects evaluated for ecological impacts through an informed decision-making (comprehensive environmental review) process due to project		
8.12	**Maintain enterprise-wide habitat connectivity**	Change in road miles/square miles of watershed due to project	Change in number of fish passage barriers/hydrological obstructions in right-of-way due to project	Change in the number of retrofitted/maintained drainage and crossing structures due to project		
8.13	**Develop projects that maintain and improve quantity and quality of water and aquatic ecosystems**	*Change in number [percentage] of projects designed to maintain or improve water quantity or quality*				
8.14	**Maintain and improve surface water quantity and quality during project implementation**	Change in the amount of net impervious surface area (acres) due to project	Change in the amount of aquatic habitat impacted (i.e., wetlands [acres], stream channel [feet, square feet]) due to project			

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 3: Project Development (Continued)						
8.15	**Design projects that allow normal physical processes within the stream-floodplain corridor**	Change in the number of new and retrofitted water crossings other than overflow crossings that: (1) promote natural sediment transport patterns for the reach, (2) provide unaltered fluvial debris movement, and (3) allow for longitudinal continuity and connectivity of the stream-floodplain system due to project	Change in the number of new and retrofitted water crossings that allow lateral connectivity between the stream and floodplain due to project			
8.16	**Develop projects to be free of contaminants and pollutants**	Change in the percentage of projects covered by a documented Environmental Management System	Change in the number of projects developed for remediation of contaminated sites			

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 4: Construction						
8.17	**Promote biodiversity during project implementation**	Number of biological communities, species, populations, and genetic assemblages eliminated from effect zones due to construction				
8.18	**Control dispersal and establishment of invasive species during project implementation**	Number of projects implementing integrated pest management or weed control plans during construction				
8.19	**Apply context sensitive corridor habitat restoration and landscaping during project implementation**	*Ratio of restored and maintained area to disturbed area (acres) within project*				
8.20	**Reduce noise and light impacts on fish and wildlife during project implementation**	Amount and duration of priority habitat exposure to high levels of noise/light during construction				
8.21	**Reduce herbicide use during project implementation**	Area (in acres) sprayed with herbicides during construction				
8.22	**Reduce exposure to pollutants and contaminants during project implementation**	Amount of hazardous materials accidentally spilled (e.g., number of spills, gallons spilled, spills per million gallons shipped) during construction				

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 5: Maintenance						
8.23	**Promote biodiversity during project maintenance**	Number of biological communities, species, populations, and genetic assemblages eliminated from effect zones due to maintenance				
8.24	**Control dispersal and establishment of invasive species during project maintenance**	Number of projects implementing integrated pest management or weed control plans during maintenance				
8.25	**Apply context sensitive corridor habitat restoration and landscaping during project maintenance**	Ratio of restored and maintained area to disturbed area (acres) due to maintenance				
8.26	**Reduce noise and light impacts on fish and wildlife during project maintenance**	Amount and duration of priority habitat exposure to high levels of noise/light during maintenance				
8.27	**Reduce herbicide use during project maintenance**	*Area (in acres) sprayed with herbicides during maintenance*				
8.28	**Reduce exposure to pollutants and contaminants during project maintenance**	Amount of hazardous materials accidentally spilled (e.g., # of spills, gallons spilled, spills per million gallons shipped) during maintenance				

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 6: System Operations						
8.29	**Operate facilities to promote ecological opportunities, ecosystem benefits, and the building of natural capital**	Change in number of projects using spatially-related (i.e., GIS-based) ecological condition inventories for managing healthy ecological systems				
8.30	**Conserve natural resources/capital during operations**	Change in amount of managed natural resource area by habitat type (acres)	Change in the area of previously established resource replacement mitigation disturbed by operations (acres)			
8.31	**Reduce vehicle-animal collisions during operations**	*Change in the number of animal kills*				
8.32	**Control dispersal and establishment of invasive species during operations**	Change in number of noxious species in right-of-way				
8.33	**Apply context sensitive corridor habitat restoration and landscaping during operations**	Change in amount [percentage] of operational budget allocated for landscape maintenance				

Goal 8. Ecosystems—Protect and enhance environmental and ecological systems while developing and operating transportation systems.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 6: System Operations (Continued)						
8.34	**Manage facilities to be pervious to the movements of biological organisms**	Change in the amount [percentage] of operational budget allocated for habitat connectivity	Change in the amount [percentage] of operational budget allocated for maintenance of hydrology			
8.35	**Reduce noise and light impacts on fish and wildlife during operations**	Change in the amount of priority habitat areas exposed to high levels of transportation noise/light [due to operational improvements]				
8.36	**Maintain surface water quantity during operations**	Change in the number of water detention facilities in operation				
8.37	**Allow normal physical processes within the stream-floodplain corridor during operations**	Change in the percentage of channel crossings with properly functioning fluvial processes	Change in the percentage of floodplain crossings with properly functioning fluvial processes			
8.38	**Reduce herbicide use during operations**	Change in area (in acres) sprayed with herbicides during construction and maintenance				
8.39	**Reduce exposure to pollutants and contaminants during operations**	Change in the number of extant contaminated sites in right-of-way				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning						
9.1	**Reduce total waste created**	Change in the amount of waste generated by type, weight, and/or volume				
9.2	**Increase the percentage of waste diverted**	Change in the amount of waste diverted (from landfull) by type, weight, and/or volume				
9.3	**Reduce hazardous waste**	Change in the amount of hazardous waste generated by type, weight, and/or volume				
9.4	**Clean up existing hazardous waste**	Change in the quantity of hazardous waste cleaned up compared to waste generated (e.g., acres of brownfield, gallons of waste, amount of treated groundwater, etc.)				
9.5	**Ensure transportation infrastructure (e.g., pavements, bridges etc.) is designed for long life**	Change in the average structural life of infrastructure network (e.g., pavement, bridge, tunnels, etc.)				
9.6	**Ensure that assets are managed to reduce life cycle cost and increase useful life**	*An asset management system exists*				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
9.7	**Reduce total waste created by transportation projects**	Change in the amount of waste generated by type, weight, and/or volume due to program	Change in the percentage of projects with a waste management plan in compliance due to program			
9.8	**Increase the percentage of waste diverted from transportation projects**	Change in the amount of project waste diverted (from landfull) by type, weight, and/or volume due to program	Change in the percentage of projects with of a recycling plan or waste diversion goal due to program			
9.9	**Reduce hazardous waste generated by transportation projects**	Change in the amount of hazardous waste generated due to program				
9.10	**Clean up existing hazardous waste**	Change in the quantity of hazardous waste cleaned up compared to waste generated (e.g., acres of brownfield, gallons of waste, amount of treated groundwater, etc.) due to program				
9.11	**Program infrastructure projects designed for long life**	*Change in average design life of infrastructure [by major component] due to program*				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
9.12	**Reduce total waste created by transportation projects**	Change in the amount of waste generated by type, weight, and/or volume due to project	Change in the percentage of projects with a waste management plan in compliance			
9.13	**Increase the percentage of waste diverted from transportation projects**	Change in the amount of project waste diverted (from landfull) by type, weight, and/or volume	*Change in the percentage of projects with of a recycling plan or waste diversion goal*			
9.14	**Reduce hazardous waste generated by transportation projects**	Change in the amount of hazardous waste generated due to project				
9.15	**Clean up existing hazardous waste**	Change in the quantity of hazardous waste cleaned up compared to waste generated (e.g., acres of brownfield, gallons of waste, amount of treated groundwater, etc.) due to project				
9.16	**Develop infrastructure projects designed for long life**	Change in average design life of project infrastructure [by major component]				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
9.17	**Reduce total waste created during construction**	Change in the amount of waste generated by type, weight, and/or volume during construction	Change in the percentage of projects with a waste management plan in compliance			
9.18	**Increase the percentage of waste diverted during construction**	*Change in the amount of construction waste diverted (from landfill) by type, weight, and/or volume*	Change in the percentage of construction projects with a recycling plan or waste diversion goal			
9.19	**Reduce hazardous waste generated during construction**	Change in the amount of hazardous waste generated by project construction				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 5: Maintenance						
9.20	**Reduce total waste created during maintenance**	Change in the amount of waste generated by type, weight, and/or volume during maintenance				
9.21	**Increase the percentage of waste diverted during maintenance**	Change in the amount of maintenance waste diverted (from landfull) by type, weight, and/or volume	*Change in the percentage of maintenance projects with a recycling plan or waste diversion goal*			
9.22	**Reduce hazardous waste generated during maintenance**	Change in the amount of hazardous waste generated during maintenance				

Goal 9. Waste Generation—Reduce waste generated by transportation-related activities.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
9.23	**Reduce total waste created due to system operations**	Change in the amount of waste generated by type, weight, and/or volume due to system operations	Change in the percentage of projects with a waste management plan in compliance			
9.24	**Increase the percentage of waste due to system operations that is diverted**	Change in the amount of operations waste diverted (from landfull) by type, weight, and/or volume	Change in the percentage of operational activities with of a recycling plan or waste diversion goal			
9.25	**Reduce hazardous waste generated due to operations**	Change in the amount of hazardous waste generated by operational activities				
9.26	**Reduce litter**	*Change in the quantity of total litter collected annually (weight, volume, etc.)*				
9.27	**Increase composting, reuse of existing vegetation, and clearing/grubbing waste**	Change in total weight/volume composted annually				
9.28	**Reduce use of toxic cleaners, pesticides, and other chemicals**	Change in the total quantity used annually (weight, volume, etc.)				
9.29	**Ensure transportation infrastructure is operated for long life**	Change in the average actual life of infrastructure [by major component]				
9.30	**Ensure that assets are managed to reduce life cycle cost and increase useful life**	An asset management system is actively operated				

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning						
10.1	**Maintain a sustainable fleet**	Change in the percentage of zero/low emissions vehicles in DOT fleet	Change in the percentage of total diesel fuel substituted with alt fuels, ULSD, electric motors			
10.2	**Purchase sustainable materials as a priority**	*Existence of a purchasing plan that establishes priority for sustainable materials*	Change in percentage of sustainable materials (by weight, volume, or dollar value)			
10.3	**Use renewable energy to provide project power**	Change in percentage of renewable energy, in kWh, created in relation to energy requirements				
10.4	**Reduce the demand for SOV travel**	Change in the number [or cost] of multimodal options for state employees				
10.5	**Purchase green energy**	Change in the amount and percentage of green energy purchased				
10.6	**Reduce energy usage**	Change in total energy consumed by DOT facilities [should relate to quantity of facilities]	Change in the number [or value] of investments in operational technologies to reduce fuel consumption (IdleAire, APUs supported by DOT through CMAQ)	Percentage of trucks with Smartway type technologies		
10.7	**Provide electric vehicle infrastructure**	Change in the number of plug-in stations, amount of energy distributed from those stations	Change in percentage of truck stops with electrification (IdleAire, etc.)			

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 2: Programming						
10.8	**Encourage the sensible use of recycled materials in project programming**	Existence of a policy or specification prioritizing the use of sustainable materials in program	Change in percentage of sustainable materials (by weight, volume, or dollar value) due to program			
10.9	**Encourage the use of renewable energy in project programming**	*Change in percentage of renewable energy, in kWh, created in relation to project energy requirements due to program*				
10.10	**Program projects that use less energy**	Change in the number and percentage of projects in program that have lighting meeting Energy Star requirements				

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 3: Project Development						
10.11	**Develop projects that encourage the sensible use of recycled materials**	Change in percentage of sustainable materials (by weight, volume, or dollar value) due to project				
10.12	**Use renewable energy to provide project power**	*Change in percentage of renewable energy, in kWh, created in relation to project energy requirements in project*				
10.13	**Develop projects that use less energy**	Change in the number and percentage of projects that have lighting meeting Energy Star requirements				

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 4: Construction						
10.14	**Use biofuel for non-road construction equipment**	*Percentage of machine-hours or gallons of biofuel used during construction*				
10.15	**Purchase regionally-produced construction materials**	Total weight/volume/cost purchased within a certain radius (e.g., 500 miles) from the project				
10.16	**Reduce energy usage due to construction**	Total machine-hours of energy efficient non-road equipment as a percentage of all construction-related machine-hours				

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	**Objectives**	**Measure A**	**Measure B**	**Measure C**	**Measure D**	**Measure E**
Focus Area 5: Maintenance						
10.17	**Use biofuel for non-road maintenance equipment**	*Percentage of machine-hours or gallons of biofuel used during maintenance*				
10.18	**Purchase regionally-produced maintenance materials**	Total weight/volume/cost purchased within a certain radius (e.g., 500 miles) from the project				
10.19	**Reduce energy usage due to maintenance**	Total machine-hours of energy efficient non-road equipment as a percentage of all maintenance-related machine-hours				

Goal 10. Resource Consumption—Reduce the use of non-renewable resources and promote the use of renewable replacements.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
10.20	**Maintain a sustainable fleet**	Change in the percentage of zero/low emissions vehicles in DOT fleet	Change in the percentage of total diesel fuel substituted with alt fuels, ULSD, electric motors			
10.21	**Purchase sustainable materials as a priority**	Sustainable purchasing plan that defines and establishes priority for sustainable materials (e.g., recycled, reused, local, etc.)				
10.22	**Purchase green energy**	*Change in the amount and percentage of green energy purchased*				
10.23	**Reduce energy usage due to operations**	Change in the number of energy efficient fixtures, total kWh saved, etc.	Change in percentage of renewable energy, in kWh, created in relation to operations energy requirements			

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning						
11.1	**Reduce activity that generates pollutant emissions (travel, trip length, mode split, emissions)**	Change in trips, vehicle trips, VMT, percent non-driver, tons of emissions per day	Change in percentage of commercial vehicles by EPA Tier compliance			
11.2	**Reduce polluting exhaust emissions (criteria pollutants and GHGs)**	Change in emissions by criteria pollutant, total, and by mode/ton mile	Lane miles of new access improvements to intermodal and port facilities	Number of new separated rail crossings replacing grade crossings		
11.3	**Increase land use compactness, density, and balance of interacting uses (compactness, density, balance)**	Change in jobs/housing balance	Change in zoned residential density levels around essential service hubs			
11.4	**Increase the use of non-motorized modes**	Change in planned miles of transit routes, pedestrian facilities, designated bike facilities, population within 1 mile of transit, connectivity index (pedestrian facilities, bike facilities, transit routes				
11.5	**Increase street connectivity**	*Change in street connectivity index*				
11.6	**Reduce congestion; promote low emissions travel speeds**	Change percent VMT at low emission speed ranges	Change in percentage of toll lanes with EZPass			

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 1: Planning (continued)						
11.7	**Reduce proximity of air pollution-sensitive land uses to major pollution sources (high volume highways)**	Change in sensitive receptors within close proximity, residential population within critical distance, percentage of ethnic/racial population groups within critical distance				
11.8	**Reduce concentration of critical pollutants in populated areas (model forecast) (criteria pollutants, GHGs)**	Change in population within areas above EPA standard [non-attainment areas?], percent of ethnic/racial population groups within areas above EPA standard, percent school population within areas above EPA standard				
11.9	**Provide measures that can reduce air pollutant concentrations (e.g., landscaping)**	Change in $CO_2 \rightarrow O_2$ conversion capacity of planned ROW plant materials				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming						
11.10	**Program projects that reduce pollutant emissions (travel, trip length, mode split, emissions)**	Change in trips, vehicle trips, VMT, percent non-driver, tons of emissions per day due to program	*Change in percentage of commercial vehicles by EPA Tier compliance due to program*	Change in emissions by criteria pollutant, total, and by mode/ton mile due to program	Lane miles of new access improvements to intermodal and port facilities due to program	Number of new separated rail crossings replacing grade crossings due to program
11.11	**Increase use of non-motorized modes**	Change in route or service miles of: transit routes, pedestrian facilities, designated bike facilities, population within 1 mile of transit, person-miles walk distance to transit stops, person-miles distance from building entrances to public pedestrian facilities (sidewalks, pedestrian ways), connectivity index: (pedestrian facilities, bike facilities, transit) due to program				
11.12	**Increase street connectivity**	Change in street connectivity index due to program				
11.13	**Reduce congestion; promote low emissions travel speeds**	Change in percent VMT at low emission speed range; total vehicle delay; percent stops (of intersection approach volumes); multimodal level of service (by mode); percent VMT at each level of service due to program				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 2: Programming (Continued)						
11.14	**Reduce populations within critical distance of major highway emissions sources (criteria pollutants, GHGs)**	Change in population within critical distance of high volume highways (specify threshold ADT) (schools, hospitals, residences, ethnic/racial group equity) due to program				
11.15	**Reduce traffic volumes on major highways within critical distance of sensitive receptors (schools, hospitals, residences, ethnic/racial equity)**	Change in ADT (total, diesel), emissions due to program				
11.16	**Provide measures that can reduce air pollutant concentrations (e.g., landscaping)**	Change in $CO_2 \rightarrow O_2$ conversion capacity of project plant materials due to program				
11.17	**Reduce travel speeds to those within the lowest emissions ranges (criteria pollutants, GHGs)**	Change in population percentage within a critical distance of traffic operating at speeds outside the lowest emissions range due to program				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development						
11.18	**Develop projects that reduce pollutant emissions (travel, trip length, mode split, emissions)**	Change in trips, vehicle trips, VMT, percent non-driver, tons of emissions per day due to project	*Change in percentage of commercial vehicles by EPA Tier compliance due to project*	Change in emissions by criteria pollutant, total, and by mode/ton mile due to project	Lane miles of new access improvements to intermodal and port facilities due to project	Number of new separated rail crossings replacing grade crossings due to project
11.19	**Increase use of non-motorized modes**	Change in route or service miles of: transit routes, pedestrian facilities, designated bike facilities, population within 1 mile of transit, person-miles walk distance to transit stops, person-miles distance from building entrances to public pedestrian facilities (sidewalks, pedestrianways), connectivity index: (pedestrian facilities, bike facilities, transit) due to project				
11.20	**Increase street connectivity**	Change in street connectivity index due to project				
11.21	**Reduce congestion; promote low emissions travel speeds due to project**	Change in percent VMT at low emission speed range; total vehicle delay; percent stops (of intersection approach volumes); multimodal level of service (by mode); percent VMT at each level of service due to project				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 3: Project Development (Continued)						
11.22	**Reduce populations within critical distance of major highway emissions sources (criteria pollutants, GHGs)**	Change in population within critical distance of high volume highways (specify threshold ADT) (schools, hospitals, residences, ethnic/racial group equity) due to project				
11.23	**Reduce traffic volumes on major highways within critical distance of sensitive receptors (schools, hospitals, residences, ethnic/racial equity)**	Change in ADT (total, diesel), emissions due to project				
11.24	**Provide measures that can reduce air pollutant concentrations (e.g., landscaping)**	Change in $CO_2 \rightarrow O_2$ conversion capacity of project plant materials due to project				
11.25	**Reduce travel speeds to those within the lowest emissions ranges (criteria pollutants, GHGs)**	Change in population percentage within a critical distance of traffic operating at speeds outside the lowest emissions range due to project				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 4: Construction						
11.26	**Reduce construction activity that generates pollutant emissions (engine operation, engine emission rates, idling time, emissions)**	Engine-hours of operation, emission rates, idling hours per day, tons of emissions per day due to construction				
11.27	**Reduce adverse impact on traffic operations (lane reductions, traffic interruptions, detours, night operations)**	Change in peak hour/period capacity (e.g., lane miles), vehicle hours of delay, extra VMT, percent of passing VMT affected by construction				
11.28	**Reduce equipment emissions (equipment conforming to latest EPA emissions standards)**	*Percent of construction equipment at each tier of emissions standards (weighted or unweighted), percent of construction equipment retrofitted to meet latest EPA emissions standards*				
11.29	**Reduce on-site construction equipment activity**	Percent change in hours of diesel equipment operation compared to conventional techniques, percent of construction completed off-site (e.g., precast)				
11.30	**Reduce construction equipment emissions within a critical distance of sensitive populations (schools, hospitals, residences, ethic/racial group equity)**	Daily emissions within critical distance (criteria pollutants, GHGs) due to construction				
11.31	**Reschedule urban construction activity with high emission rates to periods of low pollutant concentrations**	Percentage of diesel construction equipment operating hours during low pollutant concentration hours				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 5: Maintenance						
11.32	**Reduce maintenance activity that generates pollutant emissions (engine operation, engine emission rates, idling time, emissions)**	Engine-hours of operation, emission rates, idling hours per day, tons of emissions per day due to maintenance				
11.33	**Reduce adverse impact on traffic operations (lane reductions, traffic interruptions, detours, night operations)**	*Change in peak hour/period capacity (e.g., lane miles), vehicle hours of delay, extra VMT, percent of passing VMT affected by maintenance*				
11.34	**Reduce equipment emissions (equipment conforming to latest EPA emissions standards)**	Percent of maintenance equipment at each tier of emissions standards (weighted or unweighted), percent of maintenance equipment retrofitted to meet latest EPA emissions standards				
11.35	**Reduce maintenance equipment emissions within a critical distance of sensitive populations (schools, hospitals, residences, ethic/racial group equity)**	Daily emissions within critical distance (criteria pollutants, GHGs) due to maintenance				
11.36	**Reschedule urban maintenance activity with high emission rates to periods of low pollutant concentrations**	Percentage of diesel maintenance equipment operating hours during low pollutant concentration hours				

Goal 11. Emissions and Air Quality—Reduce transportation-related emissions of air pollutants and greenhouse gases.						
#	Objectives	Measure A	Measure B	Measure C	Measure D	Measure E
Focus Area 6: System Operations						
11.37	**Reduce congestion-related emissions**	Change in the percent of VMT at low emission speed ranges, total vehicle delay, percent of approaching traffic that is stopped, multimodal level of service (by mode)	Change in emissions by criteria pollutant, total, and by mode/ton mile due to operational improvements			
11.38	**Reduce engine idling (on-road, non-road)**	Change in vehicle-hours of idling				
11.39	**Promote non-motorized modes**	Change in multimodal level of service, percent telework jobs (person-days/week), percent jobs within __ minutes of population (average) by non-motorized modes, percent population within 1/4 miles of transit service, percent jobs within 1/4 mile of transit service, percent jobs within 1/2 mile of designated bike route, percent population within 1/2 mile of designated bike routes, average auto/transit travel time ratio (selected corridors)				
11.40	**Maintain efficient traffic operations**	Percent of area traffic signals retimed during past three years, percent of area traffic signals within coordinated signal systems recoordinated during past three years	*Change in percentage of toll payers using EZPass*			
11.41	**Promote driving shifts to non-school hours**	Change in percent [volume] of traffic passing school zones during times when schools are not in session				
11.42	**Promote non-motorized modes**	Change in the percentage of PMT by non-motorized modes; emissions				

APPENDIX F—EXAMPLES OF APPLICATIONS

Throughout literature, many examples exist of the use of performance measures by transportation agencies for sustainability and other purposes. As discussed in the report, there are five main types of applications of performance measures:

- Description.
- Evaluation.
- Accountability.
- Decision support.
- Communication.

This appendix contains examples of practical use of performance measures (sustainability measures and other performance measures) that cover all five application types and provide further information on how performance measures can be used for different applications. The examples often cut across application types and do not always specifically address a single type of application. However, they provide a snapshot of how these application types have been used in practice.

City of Hamilton, Canada, Triple Bottom Line Toolkit

The City of Hamilton, Canada, has a Triple Bottom Line (TBL) toolkit that is used "as a framework for assessing social, economic, and environmental considerations in an integrated manner" (*1*). This tool aids municipalities in identifying and defining sustainability issues, taking the legislative process into consideration. The TBL Tool was created to aid in evaluation of options for long-range planning initiatives "that will identify a broad range of land use structures, associated infrastructure, economic development strategy, and the financial implications of growth options in Hamilton" (*2*). Training workshops were conducted to help participants learn not only how to use the tool but how to apply TBL concepts within local governments. After forecasting the data, each option is assigned a score based on performance (i.e., positive impact, neutral, or negative impact) for the three TBL categories: community and social well-being impacts, economic impacts, and environmental impacts. Scores are assigned based on overall desired results, rather than individual considerations (*3*). The scoring of multiple options helps the city in making a decision on the best option to pursue.

Balanced Scorecard, Logistics Center of the Federal Aviation Administration

The Logistics Center of the Federal Aviation Administration used the principles behind the Balanced Scorecard Approach to develop strategic objectives, performance measures, and targets set for one to three years out (*4*).

Intergovernmental Panel on Climate Change IPAT Application

The Intergovernmental Panel on Climate Change used the "Impact, Population, Affluence, Technology" (IPAT) theory and approach to diagnose the major driving forces behind anthropocentric GHG emissions as part of its *IPCC Special Report on Emissions Scenarios* in 2000 (*5*).

Public Service Agreements (U.K. Government)

The government in the United Kingdom has been using public service agreements (PSAs) as part of its Comprehensive Spending Review since 1998 (*6*). For each PSA, there is a delivery agreement that indicates the plans of delivering desired results and the role of delivery partners. Each delivery agreement applies to all contributing government departments. Each PSA also includes a set of performance indicators that measures progress toward the goal of each PSA. Some indicators include numeric targets or standards. For example, PSA Agreement 27 addresses the goal to "lead the global effort to avoid dangerous climate change" (*7*). The report includes a vision of what this means, a set of six performance indicators, and a delivery strategy with many aspects that address various departments. Example indicators include "global CO_2 emissions to 2050" and "proportion of emissions reductions from new policies below the Shadow Price of Carbon." The lead department for this PSA is the Department for Environment, Food, and Rural Affairs (Defra). Other departments involved with this PSA include the Department for Transport (DfT), the Department for Business, Enterprise, and Regulatory Reform (BERR), and the Department of Health (DH). The report outlines specific roles and responsibilities for each department involved. By specifically stating all of this, the PSA increases accountability to the public and stakeholders.

New Hampshire DOT Cost-Benefit Analysis

Cost-benefit analysis is used frequently to determine if a project is beneficial or to compare project alternatives; thus, many examples exist. One such example is a bridge replacement project under the jurisdiction of the New Hampshire Department of Transportation (NHDOT) (*8*). Many aspects of the project were considered in terms of costs and benefits. Long-term benefits identified for this project include:

- Pavement maintenance savings.
- Maintenance and operating cost savings.
- Vehicle operating cost savings.
- Long-term employment.
- Travel-time savings.
- Pedestrian and health benefits.
- Emissions reductions.
- Accident reduction.
- Short-term employment.

Most of the benefits can be described as cost reductions in the long term. Many can also be quantified as estimated cost reductions based on reduced travel and reduced travel time as a result of the new bridge, although not all benefits were included in the final analysis. Monetization was used in that more abstract aspects such as emissions and the health benefit of walkability had to be represented in a unit of money. Dollar amounts were based on the effects of the build versus no-build scenarios. The costs associated with the project included the construction cost and the operating and maintenance cost.

Miscellaneous Examples of Communication of Performance Measures

As discussed in this report, the communication of performance measures can be viewed as a cross-cutting application that can support other applications of performance measurement. A few examples of communication of performance measures by transportation agencies are as follows:

- Traffic light indicator by the Colorado DOT (*9*).
- Florida DOT performance scorecard (*10*).
- Virginia DOT dashboard of performance measures (*11*).
- Texas Department of Transportation (TxDOT) pavement condition (*12*).

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APPENDIX G—BUILDING A RATING SYSTEM

Currently there are a number of national and international efforts within the transportation community aimed at producing sustainability rating systems. In general, these systems are designed to provide guidance, scoring, and potential rewards for including sustainable attributes in a roadway project. Rating systems are appealing because they:

- Provide a common metric (points) for the entire range of sustainable solutions.
- Measure sustainability and thus make it manageable.
- Allow for straightforward communication of sustainability goals, efforts, and achievement.
- Provide a reasonable context within which designers, contractors, and material suppliers can be innovative in their solutions.

Rating systems are most often criticized because they tend to sacrifice detail for simplicity, it is difficult to generate consensus on the items to be included/excluded, they do not capture the entire scope of sustainable solutions, and pursuing points in a rating system may trump good design/construction and ultimately lead to poorer projects. This section provides assistance in developing a rating system in the form of key attributes and development steps. Appendix A contains many useful resources for developing rating systems for sustainability.

KEY ATTRIBUTES OF A SUSTAINABILITY RATING SYSTEM

The following discusses 12 key attributes of a sustainability rating system. It may not be possible to incorporate all of these attributes into a single rating system, but the relative importance of each should be established and thoughtfully considered when developing a rating system.

Sustainability definition. A rating system should clearly and precisely define sustainability in a way that helps develop actions to support the definition. It should go beyond the general Brundtland Commission Report statement and go beyond loosely defining the standard three dimensions (environmental, economic, and social).

Scope. A rating system should have a clear and precise scope. Components of roadway development that may or may not be addressed include planning, project development, design, construction, operations, and maintenance.

Validation. A rating system should be tested on actual projects in order to refine its use and calibrate its scoring. It should be vetted by stakeholders but should also be independent and not beholden to stakeholder special interests.

Relation to existing regulation. Many sustainability criteria are already addressed by existing U.S. regulation (e.g., National Environmental Policy Act, Clean Water Act, and Clean Air Act). While these items should not be forgotten, they should not be the focus of a rating system. Rather, a rating system should assess decisions regarding sustainability options *where they are not precluded by regulation or where regulation allows a choice between options.* Importantly, a sustainability rating system should not dictate design or trade-off decisions. Rather, it should provide a tool to help evaluate such decisions. As existing regulations evolve, the rating system should be updated to keep its compatibility intact.

Weighting and scoring logic. A rating system should weight individual items based on the impact on sustainability (i.e., assign them point values). Further, a rating system should have a general framework from which it draws the weighting of individual criteria in relation to one another. Life cycle assessments, life cycle cost analyses, and other valuations suggest some actions have more impact on sustainability than others; so, in a point-based system, some actions earn more points than others depending on impact. Additionally, this scoring framework should be transparent and empirically based to the extent possible. In other words, users should understand how it was developed, and it should reflect some greater scheme beyond what a particular individual or group believes weighting should be. While it is not likely such a weighting framework can be universally agreed upon, it can nonetheless be developed.

Context sensitivity. Like sustainability itself, a rating system should be context sensitive or adaptable. It should work for small projects as well as large projects. There should be a provision for adding to the system based on new ideas, and there should be a way for an organization to use the system within the context of its specific sustainability goals and objectives. This generally means having a voluntary subset of criteria from which a project can pick and choose those it values. It also means having a means by which a project can trace its values to specific criteria.

Independent third-party rating. For the highest level of credibility, a rating system should be scored by an independent, accredited third party to avoid the appearance of impropriety. This also provides an element of peer review, a concept well established in roadway development with ideas like value engineering. A self-evaluation tool can also be acceptable if the system is meant to serve as an internal metric only.

Well-defined credits and actions. Individual credits and required documentation must be clearly stated and quantifiable in specification-like language in order to avoid ambiguity. Otherwise, there is a temptation to liberally assign points or give credit where ambiguity exists. Terms like “maximize,” “as much as possible,” and “most efficient use of” are ambiguous and should be avoided.

Substantiated credits. Individual credits should be substantiated by a body of empirical evidence. Evidence that suggests how a credit contributes to sustainability, points out flaws and weaknesses, and suggests implementation strategies is useful and should be present.

Transparency. Key decisions regarding system development (e.g., scoring, weighting, reasons why items are or are not considered sustainable, etc.) should be documented and available for public viewing. This also includes stating potential costs and benefits, where known.

Encouragement to improve on current practice. The goal of a rating system should be to encourage organizations to do things that they normally have not done in the past (i.e., improve). It should not exist solely to harvest credit for things already done as standard practice. Therefore, current standard practice should not score high in a rating system.

Dynamic Nature of the System. As roadway industry sustainability savvy grows, in the future a rating system should also change so that it remains current. In this way such a system can continue to encourage improvement beyond current standard practice, whatever that standard may be.

RATING SYSTEM DEVELOPMENT STEPS

The following provides a very general guide to developing a sustainability rating system. It builds on the key components of a rating system and provides some guidance on how to integrate them into the development process.

1. **Address sustainability as an agency**. A rating system should be viewed as one tool among many that can assist an organization in measuring, managing, and achieving its sustainability goals. It should not be viewed as a sustainability policy in and of itself. Therefore, the best time to develop a rating system is after an organization has determined its overall approach to sustainability. This more overarching idea then forms the foundation for determining what a rating system measures and how the results are to be used. Ideally, an agency committed to sustainability will have a short list of specific goals and metrics. Rating systems should measure these goals and inputs.

2. **Determine the purpose**. Based on the agency's approach to sustainability, there may be one or more areas where a rating system could provide value. While lowest life cycle cost, less environmental impact, and better societal outcomes are often identified as key outcomes from a rating system, these are more likely key outcomes associated with an agency's sustainability efforts in general and are not directly attributable to the existence of a rating system. However, a rating system may help encourage these outcomes by communicating sustainability in a meaningful manner internally and to the general public, and recognizing/rewarding sustainability. Typically, agencies have preferred to develop rating systems as internal performance metrics (e.g., NYSDOT) rather than external cross-agency metrics (e.g., Greenroads).

3. **Establish a scope**. Rating system scopes can be broad or narrow. At the broadest level, rating system scopes can include high-level agency policies (e.g., sustainability plan, land use planning, or priority programming), network-wide operations, and maintenance (e.g., asset management, network mobility, or sustainable purchasing plan) as well as items specific to a particular project. At the narrowest level, the rating system scope can be limited to a specific portion of individual projects (e.g., the pavement, drainage system, or congestion management systems). In general, the more theoretical the approach, the more it includes; the more practical the approach, the less it includes. In general, larger scopes (e.g., those that include planning, projects, operations, maintenance, policy, etc.) result in more theoretical buy-in (e.g., more interest groups see their particular specialty represented and thus feel included), more controversy (e.g., interest groups tend to be unhappy with the simplicity with which the system represents their specialty), and longer/more expensive development periods (e.g., large scopes result in more work). To date, project-level rating systems are most popular. For instance, LEED®, Greenroads™, and CEEQUAL are all project-level systems. Rating projects results in a score given to actual physical infrastructure. This is usually most appealing to the general public since infrastructure is the most identifiable agency product to

the non-expert. It is more difficult to establish the meaning of a score given to a process (e.g., land use planning) although it can be done.

4. **Determine topics**. Apply the given scope to the agency sustainability definition in order to determine the topics to be addressed by the rating system. These can be broad sustainability-related topics (e.g., energy, clean water, clean air, mobility, safety, etc.) or can be more transportation-focused topics (e.g., electric car infrastructure, construction equipment emissions reduction, transit access, etc.). Check to ensure that the developed topic list covers all components of sustainability (as defined by the agency) within the stated scope of the rating system.

5. **Determine credits**. Develop credits that apply to each topic area. There is a tendency at this point to identify specific project solutions (e.g., a bioswale used on a particular project) as a credit. However, it is better to identify the broader goal (e.g., low-impact development) and encourage creativity in identifying the specific solution that will achieve the broader goal. In almost all cases, it is not possible to establish a one-to-one relationship between topic and credit. In other words, one credit will likely apply to multiple topics, and one topic will likely have several credits. Finally, some topics may already be addressed by existing regulation. In these cases, the regulation can be identified and included in the credit list for completeness. For example, a credit for recycled materials could have a general goal of reducing lifecycle impacts from extraction and production of virgin materials, and could relate to a broad range of topics including environment/ecology, economy, fossil energy use, raw materials use, air emissions, and solid waste.

6. **Weight**. Establish a logical framework for weighting or valuing the credits in relation to one another. Weighting is controversial and imprecise. Some suggest a form of multi-criteria evaluating (MCE) as the basis for weighting. While theoretically appealing, MCE generally fails in practice because the high and low limits of existing best practices are not known, the set of alternatives being considered is essentially unknown, and such a system still generally requires a subjective weighting of credits. Thus, an MCE basis tends to obfuscate a potentially contentious issue using a process not familiar to many. Weighting can use existing information such as life cycle assessments, life cycle cost analysis, value of ecosystems, longevity of impacts, and other metrics.

7. **Test**. Evaluate existing projects, systems, or organizations using the rating system. These evaluations should test for ease of use, community receptiveness, robustness, and clarity. An ideal rating system would be easy to use, involve minimal additional work by the agency/project, be appealing to those who might use it, be able to differentiate between different levels of sustainability, and be readily understandable by the non-expert. Sample sizes should be on the order of three to five. This gives enough information to identify major trends and issues but generally not enough to draw statistically rigorous conclusions.

8. **Refine**. Refine the rating system based on feedback from testing. This could include reweighting/new/deleting credits, altering achievement levels, changing required documentation, etc.

APPENDIX H—SUMMARY OF WORKSHOPS

OVERVIEW

Based on discussion during the panel meeting held in November 2010 and subsequent discussions with the NCHRP program officer, the research team presented two interactive practitioner workshops in April 2011. The aim of these workshops was to evaluate the practical application of the framework as presented in the guidebook, test the application in practice, and incorporate feedback received, as appropriate, to further enhance the guidebook.
Additionally, another important objective of the workshop was to identify future research needs, as a part of Task 10 of the project.

The two workshops (described in Table H-1) involved a broad spectrum of transportation professionals and were held in Texas and Oregon. The Texas workshop had participants from the state DOT (TxDOT), as well as from the FHWA regional office. The Oregon workshop participants represent a range of divisions/functional areas of the Oregon DOT (ODOT).

Table H-1. Workshop Details.

	Workshop #1	**Workshop #2**
Location	Austin, Texas	Portland, Oregon
Date	April 11, 2011	April 18, 2011
Attendees	12	9
Agency Represented	TxDOT and FHWA Region 6	ODOT

WORKSHOP CONTENT

The agenda for the workshop is provided below. The workshop was planned as a day-long session with a break for lunch. The first part of the workshop was conducted in an instructional format, with members of the research team describing the basic concepts of sustainability and performance measurement, the framework developed as part of this research, and the overall research approach by means of a PowerPoint® presentation. The research products, including the guidebook and electronic compendium, were also introduced. Key material from the guidebook was also provided as handouts to the participants, and the participants were provided with a demonstration on the use of the electronic compendium of objectives and performance measures.

After the introductory lessons, the participants were divided into groups for an interactive exercise, in which they applied the framework and approach developed in the guidebook as a simplified exercise for a transportation agency. The exercise was structured to allow the participants to walk through the major steps of applying the framework to understand sustainability; identify goals, objectives, and measures; and discuss practical applications of the measures. The interactive exercise is briefly summarized as follows:

- Participants were divided into two groups and asked to represent two major divisions of a hypothetical state DOT that was in the process of restructuring (the planning division covering the focus areas of planning, programming, and project development; and the delivery division working on construction, maintenance, and operations).

- The participant brief was to:
  - Develop a position statement that defines how their division understands sustainability in the broader context of their agency.
  - Identify five goals, 10 objectives, and up to 15 performance measures using the recommended goals and the electronic compendium of objectives and measures as a starting point.
  - Discuss applications of the performance measures and data sources for their quantification.

On completion of the interactive exercise, groups were asked to report back on their findings. The workshop was then concluded with a group discussion of the process and future research needs. Participants were also requested to fill in a workshop evaluation form with further thoughts about their experience.

WORKSHOP AGENDA

NCHRP 08-74: Sustainability Performance Measures for State DOTs and Other Transportation Agencies—Interactive Workshop

09:00–09:15 Welcome and Introductions
09:15–09:30 Purpose and Overview
09:30–10:15 Background
- What does sustainability mean?
- Performance measures for sustainability
- Application of performance measures

10:15–10:30 Break
10:30–11:00 Introduction to Guidebook
- Guidebook modules
- Spreadsheet-based tool

11:00–12:00 Interactive Exercise (Part 1)
- Briefing
- Participant exercise

12:00–13:00 Lunch
13:00–14:00 Interactive Exercise (Part 2)
- Participant exercise (continues)

14:00–14:15 Group Presentation and Discussion
14:15–14:45 Discussion of Process and Future Needs
14:45–15:00 Evaluation and Closure

SUMMARY OF WORKSHOP OUTCOMES AND PARTICIPANT COMMENTS

Background and Introductory Material

The background material presented in both workshops included the basic concepts of sustainability and performance measurement, the framework developed as part of this research, and the overall research approach. In both workshops, the background discussion on sustainability and sustainable transportation generated significant discussion regarding the core understanding of sustainability and how it applied to the various participants' job functions. It was observed that

both participant groups (TxDOT/FHWA and ODOT) had an overall understanding of what sustainability meant from the perspective of transportation agencies, but somewhat lesser understanding of the application of transportation sustainability performance measures. The research team also observed that the ODOT participants debated the core principles of sustainability and the underlying philosophy of the role of the transportation sector, which could be attributed to greater existing organizational knowledge of sustainability due to ODOT's sustainability plan and related efforts. No equivalent program currently exists in Texas.

Interactive Exercise

As described previously, participants were divided into groups that represented major divisions of a hypothetical DOT. The groups were asked to perform a simplified exercise that applied the framework to develop a position statement or definition of sustainability; identify goals, objectives, and performance measures; and discuss applications of the measures and data sources as relevant to their division. The groups were provided handouts based on selected excerpts from the guidebook and given access to the electronic compendium tool to use for identifying potential performance measures. Overall, it was found that the participant groups were able to successfully perform the exercise and develop goals, objectives, and performance measures for sustainability. Many participant comments during the exercise contributed to refinements to the framework and guidebook, including the consideration of applications of the performance measurement even during initial stages of performance measure selection and the importance of a check to ensure that the principles of sustainability are being addressed.

Discussion of Research Needs

Subsequent to the interactive exercise, participants discussed potential future research needs that could build upon work performed in this research. The topics identified could broadly be classified into the following categories:

- Improved tools and methodologies for applying sustainability performance measurement.
- Capacity building and training for applying sustainability performance measurement.
- Role of strategic planning in sustainability for transportation agencies.
- Role of legislative and policy direction in sustainability for transportation agencies.
- Comprehensive sustainability implementation—integration over multiple sectors.

A more detailed discussion of these needs is presented in the final chapter of this report.

Participant Feedback and Comments

The feedback received from the workshop participants was very positive. Participants agreed that the material presented in the workshop provided them with a clearer understanding of sustainability, and that the framework presented was useful and applicable to their job. Some participants recommended that similar training be conducted on a larger scale among transportation practitioners. Others expressed the concern that while the framework was relevant and applicable, there was a need for broader policy supporting its implementation. Overall, the workshops provided the research team with the assurance that the framework and guidance developed was useful, understandable, and applicable to a broad range of transportation professionals. The specific feedback received was used to improve the guidebook and project report.