Transportation Planning for Sustainability Guidebook

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Transportation Planning for Sustainability Guidebook

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TABLE OF CONTENTS

Chapter 1: Introduction 1

Section I: Purpose of the Guidebook 2

Section II: What is Sustainable Transportation? 5

Section III: Definitions and Acronyms 10

Chapter 2: How are Sustainability Issues addressed in Transportation Planning? 13

Strategic Planning

Fiscally-constrained Planning

Performance Measurement and Performance-based Planning

Climate Change Adaptation and Mitigation

Freight Planning

Social Sustainability Assessment

Chapter 3: State of the Practice 21

Section I. Domestic practices in sustainable transportation planning 22

Section II. International practices and emerging practices in transportation planning for sustainability 31

Chapter 4: Data Collection & Availability 41

Chapter 5: Case Studies 53

Chapter 6: References 159

LIST OF TABLES

Table 1-1. Definitions of Sustainable Transportation – Examples *page 7*
Table 1-2. Sustainability principles in the mission statements of state DOTs *page 8*
Table 3-1. Summary of Environmental Sustainability Best Practices *page 23*
Table 3-2. Summary of Performance Measurement Frameworks and Reporting *page 25*
Table 3-3. Summary of Sustainability Plan/Program Best Practices *page 26*
Table 3-4. Summary of Coordinated Transportation-Land Use Best Practices *page 27*
Table 3-5. Summary of Green Transportation Rating Systems *page 28*
Table 3-6. Summary of Economic and Financial Sustainability Best Practices *page 30*
Table 4-1: Publicly Available Datasets for Transportation Analyses *page 43*
Table 4-2. Additional Transportation and Sustainability Data Sources *page 46*
Table 4-3. Applications of Data Sources in Transportation Planning and Assessment *page 48*
Table 5-1. Smart Mobility Place Types *page 65*
Table 5-2. SMPMs and Smart Mobility principles *page 67*
Table 5-3. Example "Matrix of Design Values" from Smart Transportation Guidebook *page 71*
Table 5-4. Example of related goals, target, and indicator *page 76*
Table 5-5. Reference scenario impacts over time by mode from OTP 2006 *page 108*
Table 5-6. Performance measures corresponding to each goal/objective and sustainability *page 112*
Table 5-7. Raw values for selected performance measures *page 113*
Table 5-8. Results of sustainability indexes *page 113*
Table 5-9. Summary of Key Issues, Measures, and Findings from Atlanta BeltLine HIA *page 121*
Table 5-10. Workgroups and responsibilities of Climate Change and Energy Efficiency Team *page 125*
Table 5-11. Summary of NYSDOT practices to address climate change *page 127*
Table 5-12. Potential freight CO2 savings (million tons) by 2025 *page 143*

LIST OF FIGURES

Figure 1-1: Sustainable Development and Sustainability *page 5*
Figure 3-1. Caltrans' System Management Pyramid *page 26*
Figure 3-2. Visual depiction of Sustainability Footprint method *page 34*
Figure 3-3. Schematic of a generic backcasting approach *page 39*
Figure 5-1. Transportation Planning Framework *page 61*
Figure 5-2. Framework for NZTS *page 77*
Figure 5-3. Regional Blueprints Framework *page 80*
Figure 5-4. Regional Sustainability Framework *page 84*
Figure 5-5. Development Principles of NJFIT *page 86*
Figure 5-6. Proposed Changes to Route 31 *page 88*
Figure 5-7. Transit Village Application Process *page 89*
Figure 5-8. Activity Patterns as defined by the Mobility and Community Form Guide *page 91*
Figure 5-9. Design Standards by Community Type *page 92*
Figure 5-10. Design Standards for a Regional Arterial *page 93*
Figure 5-11. Proposed initial GreenLITES certification distribution *page 98*
Figure 5-12. Snapshot from the December 2009 Gray Notebook's "Performance Dashboard" *page 103*
Figure 5-13. Illustration of Oregon DOT's three funding scenarios *page 109*
Figure 5-14. Comparison of three Atlanta regional plan alternatives using sustainability diamond *page 114*
Figure 5-15. General Process of Health Impact Assessment *page 116*
Figure 5-16. Atlanta BeltLine Concept Map *page 118*
Figure 5-17. Logic framework of potential health impacts *page 119*
Figure 5-18. 4-legged stool of transportation GHG reduction strategies *page 125*
Figure 5-19. HOT lanes configuration *page 136*
Figure 5-20. Number of Vehicle Trips Reduced at CTR sites and Employment in Washington *page 137*
Figure 5-21. West Coast Green Highway *page 137*
Figure 5-22. 2007 WSDOT GHG emissions: Total Emissions (L), Emissions by Category (R) *page 139*
Figure 5-23. 2006 CO2 emissions from the transport sectors *page 143*
Figure 5-24. Washington State Value of Freight Shipments *page 147*
Figure 5-25. Life cycle of infrastructure *page 153*
Figure 5-26. Framework and application of life-cycle assessment based on ISO guidelines *page 156*

Chapter 1:

Introduction

Section I: Purpose of the Guidebook

Why have a guidebook?

Transportation infrastructure investments have long-lasting implications not only on the transportation system but also on the larger environmental, economic, and social systems with which transportation interacts. As stated on the sustainability webpage of the American Association of State Highway and Transportation Officials (AASHTO), the sustainability of the transportation system is critical because the sector is responsible for 10 percent of the world's gross domestic product, 22 percent of global energy consumption, 25 percent of fossil fuel burning, and 30 percent of global air pollution and greenhouse gases. Transportation agencies generally do not have processes and tools to gather and sort through information on such system interactions in order to make more effective investment decisions.

Sustainable transportation is generally used to refer to transportation that contributes to the sustainable development of the community that owns and uses the system. A principal component of sustainable development, sustainable transportation tends to be defined in different ways by different agencies depending on specific priorities or constraints. However, it essentially includes effective and efficient system performance, with positive impacts on the social quality of life, economic competitiveness and the preservation of the natural environment. More recently, transportation agencies in the US have begun to develop processes and tools to gather and analyze information on system interactions in order to make more effective investment decisions. Other countries have conducted research on transportation and sustainability for several years and as a result, international experiences can provide several valuable lessons. Examples of international experiences that might be of interest include a wide range of planning and analysis tools, including Spatial Planning, Backcasting and Strategic Sustainability Analysis (SSA). Backcasting is an analytical tool that recasts the decision-making environment to better understand potential futures by deciding on the desired status of selected critical factors (e.g., related to livability, environment, and economy). Policies are then developed and implemented to promote technological innovation as well as the behaviors to achieve the desired future state. Spatial planning techniques consider spatial relationships within the context of a wide range of planning criteria, e.g. jobs/housing locations to promote economic development, environmental preservation and social quality of life. SSA, used by both Germany and the Organization for Economic Cooperation and Development to assess transportation impacts, is a model-based methodology for analyzing complex transportation decisions with long-term time horizons; interlinked with environmental, economic, and social systems; and with a spatial scope above the project-level. These types of techniques when applied at broader geographic scales, e.g. regionally or mega-regionally, tend to have more potential to promote global and regional economic competitiveness and set a general context for activities at state, county, or city levels of decision making.

There are several examples of international efforts to address sustainability, and a great deal of them have a broader scope because they are legally authorized and have allocated funding to address sustainability for entire nations and even regions. New Zealand (NZ) and the United Kingdom (UK) have national strategies for sustainable transportation. In the case of the UK, this strategy is part of a broader national sustainable development

strategy involving a number of sectors and institutions, e.g., energy and the environment. The European Union (EU) has also developed a sustainable development strategy having a transportation component. Nations and regions that invest in the development of broader sustainable development visions, goals and objectives are likely to develop more comprehensive solutions involving multiple sectors and several institutions with related functions. They are also more likely to identify confounding effects of policies that may be good for one sector, but not particularly effective for another, thus motivating agencies to work together to achieve systemic and enduring solutions.

National support for sustainability in the United States appears to be growing and one indication is the Transit Investments for Greenhouse Gas and Energy Reduction grant program included in the American Recovery and Reinvestment Act. Another development is the announcement of a partnership between the US Department of Transportation (USDOT), the US Department of Housing and Urban Development (HUD), and the US Environmental Protection Agency (EPA) for the Sustainable Communities Initiative (or Livable Communities Partnership), which represents a national movement toward collaboration among appropriate agencies to achieve sustainable development. The partnership in particular represents a broadening of the sustainability definition, as prior legislation and federal directives were focused on environmental protection and environmental justice. In addition to the environmental review process prescribed by the National Environmental Policy Act of 1969 (NEPA), US transportation agencies have been subject to planning requirements from the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21). ISTEA and TEA-21 established mandates for early identification of environmental impacts and for public involvement in the environmental review process. More recently, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2003 added mandates for Environmental Streamlining and Stewardship (1,2). Additional state and local policy guidance is provided by the Federal Highways Administration (FHWA) and AASHTO through periodic publications, workshops, and online resources. Notably, FHWA released the Sustainable Highways Self Evaluation Tool, a web-based initiative for learning about sustainability and evaluating the sustainability of roadway projects (75).

The Sustainable Highways Self Evaluation Tool is a web-based tool and resource to help transportation agencies make roadway projects more sustainable. The tool takes a lifecycle approach to sustainable roadway projects, by evaluating them from system and project planning through design, construction, and operations and maintenance. It is a voluntary, self-evaluation tool with three components. First, it offers education about sustainability principles, the FHWA Sustainable Highways Initiative, and how to apply the evaluation tool. Second, it provides examples of sustainable highways best practices. And third, it has an online form for scoring projects, programs, and agency practices. The evaluation component includes 68 credits organized into three categories: system planning, project development, and operations and maintenance. The scores provide a way quantify sustainability, information that transportation agencies can use to inform decision-making or demonstrate a commitment to sustainability. The tool is available at www.sustainablehighways.org.

Even though the US does not have a national sustainable transportation strategy to guide policy development, individual states and metropolitan areas have begun to develop their own policies, programs, and methodologies for improving transportation system sustainability. The purpose of this guidebook is to take advantage of sustainability practices around the world and describe alternatives and opportunities for implementing such practices and pointing out potential barriers. More specifically, this guidebook examines how sustainability considerations could be better incorporated into transportation planning. It focuses on practices that refine, enhance, or redefine a step(s) in the planning process, (for example, developing sustainability plans or climate change action plans). For this

reason, project-level practices that have been sponsored by organizations like FHWA or AASHTO, particularly in the area of environmental sustainability, are not covered in the guidebook, although they clearly can have an important part in a transportation agency's sustainability program.

Who is the guidebook intended for?

Many of the practices presented in this guidebook were identified from a survey of sustainability planning practices at state DOTs (refer to survey questions on page 22) and from a literature review of U.S. and international practices. As the survey results indicated, there are considerable differences in the level and type of sustainability activities in state DOTs, due in part to financial challenges, legal constraints, the presence of external support (from state government or other agencies), or different priorities. In addition, practices are undertaken at different stages of the planning process and focus on different geographic scales (local, regional, state). Because of the diversity in the practices described, this guidebook is relevant to any agency that engages in transportation planning.

How is the guidebook organized?

The guidebook presents critical issues involved in planning for sustainable transportation systems (Chapter 2) and then reviews current practices in the US and abroad that address these issues (Chapter 3). One of the major challenges in implementing sustainability assessment for planning relates to data availability, so Chapter 4 describes potential data sources and examples of how data has been used in sustainability-related initiatives. Chapter 5 consists of case studies of sustainability practices that have been implemented by US transportation agencies or comparable agencies abroad. It also describes cutting-edge evaluation methods that have not been widely applied by transportation agencies, but could greatly advance sustainability evaluation and planning.

There is a wide range of sustainability activities that can occur at transportation agencies, the focus of which put agencies on very different pathways to similar destinations. Agencies that have supporting legislation with allocated funding to pursue sustainability goals are in a different place than those that do not. An agency that already has a sustainability plan is starting from a very different place than one that has just started to talk about sustainability. Agencies that have already created interdisciplinary teams or hired new staff to deal with sustainability issues are at an advantage to those lacking personnel and experience. How an agency uses this guidebook will depend on their particular sustainability objectives and the extent of their current sustainability practices. Chapters 1, 2, and 3 can be considered a sustainability primer – a useful resource for agencies or transportation professionals that have little experience with sustainability or that want to focus on new areas that are unsustainable. The case studies presented in Chapter 5 vary widely in their level of comprehensiveness, issues addressed, and phases of the planning process impacted. Collectively, the case studies provide agencies with a range of examples from which they can select what best meets their sustainability priorities and needs.

Section II: What is Sustainable Transportation?

Sustainable Development

The classic definition of sustainable development that has enjoyed the broadest acceptance was offered by the United Nation's Brundtland Commission in 1987: Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Several definitions have emerged since. However, most definitions embrace the Brundtland concept with three fundamental components: the economy, the environment and social quality of life – also called the triple bottom line or three-legged stool of sustainable development. Successful application of the principles of sustainable development lies in translating this worthy idea into practical guidance for making decisions: i.e., setting goals, implementing practices and measuring results.

Sustainable development and sustainability are sometimes used interchangeably. Sustainable development can be viewed as the process of achieving sustainability. It relates primarily to achieving a satisfying life for all while staying within the limits of nature. To achieve sustainability, we need to balance the basic conflict between the two competing goals of ensuring an acceptable quality of life (QOL) and living within the limits of nature. If either of these elements is not achieved, we will fail in our efforts to reach sustainability (3). Figure 1-1 depicts four zones of development distinguishing among sustainable development, sustainability, and developing sustainably once sustainability has been achieved.

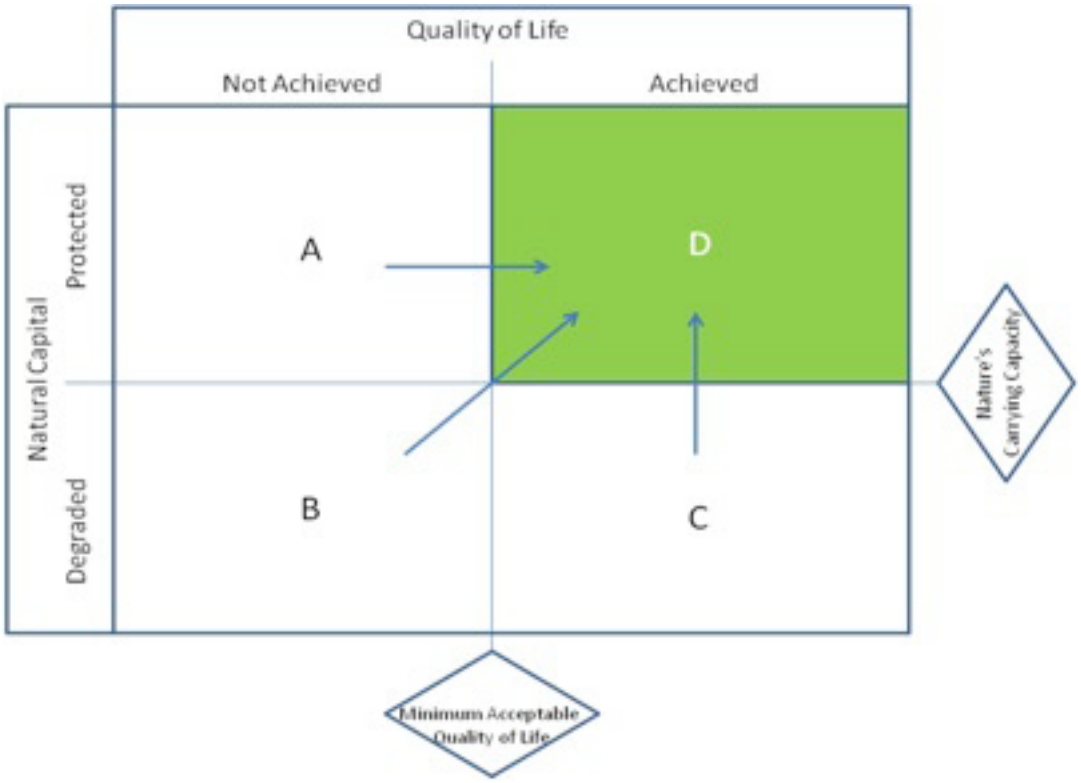

Figure 1-1: Sustainable Development and Sustainability (Chambers et al. 2000)

Sustainable development occurs as progress is made from Zones A, B or C to D. Zone A is the state where a community is denied access to natural resources and cannot meet

basic needs: for example, a community that has not developed the technology necessary to develop its natural resources and improve its QOL. Zone B, on the other hand, is the state where the environment is being degraded and yet people are not enjoying a satisfying QOL, a zone where several developing countries find themselves today. Zone C is the state where people enjoy a satisfying QOL but their natural assets are not being adequately protected, a zone where several developed countries find themselves today. Zone D, which can be considered the zone of sustainability, is a state where a high QOL has been achieved (and is being maintained or elevated) without degrading the environment. A community in Zone D can be said to have achieved sustainability in the sense that their existence does not jeopardize the natural resource capital base. But even within Zone D, there is room for "developing sustainably." A community in Zone D that finds better ways of achieving higher QOL with reduced negative impacts on its natural resources would be moving to higher levels of sustainability or developing sustainably, and becoming more resilient – economically and ecologically.

While there are several sustainability and sustainable development frameworks, this framework explains how and why sustainable development objectives can change from community to community, and even for the same community over time. The conceptual definition of sustainability can be likened to the state achieved in Zone D, where it can be shown that members of the community under consideration have a high QOL and well-protected natural resources. In this zone, some communities may be operating at superior levels of sustainability compared with others; however, all the communities in this zone would be living satisfying lives within the carrying capacities of their environments. Sustainability for each community would therefore result in the same essential condition where a good quality of life is secured for all members of the community at an expense within the carrying capacity of the environment (based on the use of natural resources and assimilation of wastes). As movements from Zone A to D, B to D and C to D can all be viewed as sustainable development pathways, the priority issues of communities in these respective zones can also be different (e.g., quality of life versus preservation of natural assets). Therefore, communities in Zones A, B and C can have different sustainable development pathways to reach Zone D.

Transportation and Sustainability

Sustainable transportation is generally used to refer to transportation that contributes to the sustainable development of the community that owns and uses the system. Various definitions adopted by different agencies tend to emphasize the elements that reflect their priorities as shown in Table 1-1, although most definitions embrace the triple bottom line factors of the economy, environment and social quality of life. Experience has shown that for transportation and other agencies to begin addressing sustainability issues, one of the first steps is to define sustainable transportation as it relates to their unique conditions.

Just over half of DOT mission statements include sustainability principles, which is a significant increase from 2005 when around one-quarter reflected sustainability (4). While no two are identical, several address impacts on the economy, environment and social quality of life. However, only two DOTs actually use the term "sustainable", and each uses unique wording and combination of principles. It is also true that not all agencies with missions that incorporate elements of sustainability can point to formal initiatives for implementing them. At the same time, there are agencies that have formal initiatives and programs for addressing sustainability but have mission statements that do not say much or anything about sustainability. Table 1-2 shows DOT mission statements with elements of sustainability.

Table 1-1. Definitions of Sustainable Transportation - Examples

Source	Definition
Ministry for the Environment, New Zealand www.mfe.govt.nz/issues/transport/sustainable/	Sustainable transport is about finding ways to move people, goods and information in ways that reduce its impact on the environment, economy and society. Some options include: (1) using transport modes that use energy more efficiently, such as walking or cycling, and public transport; (2) improving transport choice by increasing the quality of public transport, cycling and walking facilities, services and environments; (3) improving the efficiency of our car use, such as using more fuel efficient vehicles, driving more efficiently, avoiding cold starts, and car pooling; (4) using cleaner fuels and technologies; (5) using telecommunications to reduce or replace physical travel, such as tele-working or tele-shopping; (6) planning the layout of cities to bring people and their needs closer together, and to make cities more vibrant and walkable; and (7) developing policies that allow and promote these options, such as the New Zealand Transport Strategy.
Centre for Sustainable Transportation (Project funding: CST and the Government of Canada – Environment Canada and Transport Canada) (2003)	A sustainable transportation system is one that (1) Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations; (2) Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; (3) limits emissions and waste within the planet's ability to absorb them, minimizes consumption of nonrenewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.
Organization of Economic Cooperation and Development (Environment Directorate) (Project Funding: N/A) (1999)	Environmentally sustainable transportation is transportation that does not endanger public health or ecosystems and that meets needs for access consistent with (1) use of renewable resources at below their rates of regeneration and (2) use of non renewable resources below their rates of regeneration
PROSPECTS: Developing Sustainable Urban Land Use and Transport Strategies: Methodological Guidebook: Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems (Project Funding: European Commission's Energy, Environment and Sustainable Development Programme)(2003)	A sustainable urban transport and land use system: (1) Provides access to goods and services in an efficient way for all inhabitants in the urban area; (2) protects the environment, cultural heritage and ecosystems for the present generation, and (3) does not endanger opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage.
The Sustainable Transportation Action Network (Sustran), The Urban Environmental Management Research Initiative (UEMRI), Global Development Research Center (GDRC)	Sustainable transportation concerns systems, policies, and technologies. It aims for the efficient transit of goods and services, and sustainable freight and delivery systems. The design of vehicle-free city planning, along with pedestrian and bicycle friendly design of neighborhoods is a critical aspect for grassroots activities, as are telework and teleconferencing. It is more about accessibility and mobility, than about 'transportation'.

Table 1-2. Sustainability principles in the mission statements of state DOTs

State	Mission Statement
Alabama	To provide a safe, efficient, environmentally sound intermodal transportation system for all users, especially the taxpayers of Alabama. To also facilitate economic and social development and prosperity through the efficient movement of people and goods and to facilitate intermodal connections within Alabama. ALDOT must also demand excellence in transportation and be involved in promoting adequate funding to promote and maintain Alabama's transportation infrastructure.
Arkansas	It is our mission to provide and maintain a safe, effective, and environmentally sound transportation system for the state.
Connecticut	To provide a safe and efficient intermodal transportation network that improves the quality of life and promotes economic vitality for the State and the region.
Delaware	To provide a safe, efficient, and environmentally sensitive transportation network that offers a variety of convenient, and cost-effective choices for the movement of people and goods.
Florida	Provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity and preserves the quality of our environment and communities.
Georgia	Provides a safe, seamless and sustainable transportation system that supports Georgia's economy and is sensitive to its citizens and environment.
Hawaii	To provide a safe, efficient, accessible, and inter-modal transportation system that ensures the mobility of people and goods, and enhances and/or preserves economic prosperity and the quality of life
Iowa	Advocates and delivers transportation services that support the economic, environmental and social vitality of Iowa.
Illinois	To provide safe, cost-effective transportation for Illinois in ways that enhance quality of life, promote economic prosperity, and demonstrate respect for our environment.
Indiana	INDOT will plan, build, maintain, and operate a superior transportation system enhancing safety, mobility and economic growth.
Kentucky	To provide a safe, efficient, environmentally sound and fiscally responsible transportation system that delivers economic opportunity and enhances the quality of life in Kentucky.
Louisiana	To deliver transportation and public works systems that enhance quality of life and facilitate economic growth and recovery
Maine	To responsibly provide a safe, efficient, & reliable transportation system that supports economic opportunity & quality of life
Maryland	Efficiently provide mobility for our customers through a safe, well-maintained and attractive highway system that enhances Maryland's communities, economy and environment.
Michigan	Providing the highest quality integrated transportation services for economic benefit and improved quality of life
Mississippi	To provide a safe intermodal transportation network that is planned, designed, constructed and maintained in an effective, cost efficient, and environmentally sensitive manner.
Montana	To serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and sensitivity to the environment.
Nebraska	We provide and maintain, in cooperation with public and private organizations, a safe, efficient, affordable, environmentally compatible and coordinated statewide transportation system for the movement of people and goods.

State	Mission Statement
New Hampshire	Transportation excellence enhancing the quality of life in New Hampshire. Transportation excellence in New Hampshire is fundamental to the state's sustainable economic development and land use, enhancing the environment, and preserving the unique character and quality of life.
New Mexico	The primary responsibility of the agency is to plan, build, and maintain a quality state-wide transportation network which will serve the social and economic interests of our citizens in a productive, cost-effective innovative manner.
New York	It is the mission of the New York State Department of Transportation to ensure our customers - those who live, work and travel in New York State -- have a safe, efficient, balanced and environmentally sound transportation system.
North Carolina	Connecting people and places in North Carolina – safely and efficiently, with accountability and environmental sensitivity.
Ohio	Moving Ohio into a Prosperous New World. Its meaning encompasses the multi modal, safe, efficient and reliable character identified in our last business plan mission statement. At the same time, it incorporates the realization that safety, economic development, green, innovative and accessible characteristics are additional drivers needed to achieve the prosperity that will assure Ohio's future competitiveness.
Oregon	To provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians.
Rhode Island	To maintain and provide a safe, efficient, environmentally, aesthetically and culturally sensitive intermodal transportation network that offers a variety of convenient, cost-effective mobility opportunities for people and the movement of goods supporting economic development and improved quality of life.
South Dakota	We provide a quality transportation system to satisfy diverse mobility needs in a cost effective manner while retaining concern for safety and the environment.
Tennessee	To plan, implement, maintain and manage an integrated transportation system for the movement of people and products, with emphasis on quality, safety, efficiency and the environment.
Vermont	To provide for the movement of people and commerce in a safe, reliable, cost-effective and environmentally responsible manner.
Virginia	To plan, deliver, operate and maintain a transportation system that is safe, enables easy movement of people and goods, enhances the economy and improves our quality of life.
West Virginia	To create and maintain for the people of West Virginia, the United States and the world a multi-modal and inter-modal transportation system that supports the safe, effective and efficient movement of people, information and goods that enhances the opportunity for people and communities to enjoy environmentally sensitive and economically sound development.

Section III: Definitions and Acronyms

Definitions

Sustainable transportation – Transportation that promotes sustainable development.

Sustainable development – Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (from World Commission on Environment and Development)

Sustainability – A set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or the availability of natural, economic and social resources (from American Society of Civil Engineers)

Climate Change – A statistically significant variation in either the mean state of the climate or its variability over an extended period, typically decades or longer, that can be attributed to either natural causes or human activity (from TRB Special Report 290)

National Environmental Planning Act - The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet NEPA requirements federal agencies, or agencies using federal funds, prepare a detailed statement known as an Environmental Impact Statement (EIS).

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASTRA	Assessment of Transport Strategies
BTS	Bureau of Transportation Statistics
Caltrans	California DOT
CBA	Cost-Benefit Analysis
CO	Carbon Monoxide
CSD	Context Sensitive Design
CSS	Context Sensitive Solutions
CTP	Common Transport Policy
DDOT	District of Columbia DOT
DOE	Department of Energy
DOT	Department of Transportation
ECMT	European Conference of Ministers of Transport
EIA	Energy Information Administration
EIA	Environmental Impact Assessment
EJ	Environmental Justice
EPA	Environmental Protection Agency
ESCOT	Economic Assessment of Sustainability Policies of Transport
EST	Environmentally Sustainable Transport
EU	European Union
FDOT	Florida DOT
FHWA	Federal Highways Administration
FMP	Framework Program
GHG	Greenhouse gas(es)
GIS	Geographic Information System
GreenLITES	Leadership in Transportation and Environmental Sustainability
HIA	Health Impact Assessment
HUD	Department of Housing and Urban Development
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design
MCA	Multi-Criteria Analysis
MDSHA	Maryland State Highway Administration
MnDOT	Minnesota DOT
MoDOT	Missouri DOT
MPO	Metropolitan Planning Organization

NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act of 1969
NJDOT	New Jersey Department of Transportation
NOx	Nitrous Oxides
NYSDOT	New York State Department of Transportation
NZTS	New Zealand Transport Strategy
OECD	Organization for Economic Cooperation and Development
ODOT	Oregon Department of Transportation
PennDOT	Pennsylvania Department of Transportation
QOL	Quality of Life
SCS	Sustainable Communities Strategy
SEA	Strategic Environmental Assessment
SMP	System Management Pyramid
SSA	Strategic Sustainability Analysis
SSUT	Socially Sustainable Urban Transportation
T&DI	Transportation & Development Institute
TRB	Transportation Research Board
TxDOT	Texas Department of Transportation
UK	United Kingdom
USDOT	United States Department of Transportation
VIBAT	Visioning and Backcasting for Transport Policy
VMT	Vehicle miles traveled
VOC	Volatile Organic Compounds
VTrans	Vermont Department of Transportation
WSDOT	Washington State Department of Transportation

Chapter 2:

How are Sustainability Issues addressed in Transportation Planning?

Transportation planning usually tackles multiple objectives, such as setting strategic goals and priorities, measuring and monitoring progress, prioritizing initiatives to best use limited funds, and addressing new challenges like climate change and freight system capacity. The remainder of the guidebook focuses on how these issues can be addressed with sustainability as a central focus.

Strategic Planning

Strategic planning is the development of a vision, mission, and strategic objectives, and the creation of a system for evaluating progress. An agency's strategic plan shapes its activities over a multi-year period. Therefore, incorporating sustainability principles during the strategic planning process can be an effective way to implement sustainable practices for facility design, operations, and maintenance. While sustainability is commonly addressed as a section or set of goals within a strategic plan, a better approach is to transform the strategic plan into a sustainability plan. Scenario planning (especially by backcasting) or spatial planning are helpful processes for creating a strategic plan (see Chapter 3 for descriptions of these practices).

Sustainability plans and programs are important because they provide a comprehensive and coordinated way to address sustainable transportation within the agency and across complementary state agencies. There are few state DOT examples of a comprehensive sustainability plan, and one of the strongest examples of such a plan is New Zealand Ministry of Transport's sustainability-centered long-term plan. The New Zealand Transport Strategy (NZTS) 2008 establishes a set of targets to be achieved by the transportation sector over the next 30 years, and includes a performance measurement framework that is available for policymakers and the public to review progress towards the targets. The plan will also be supported statutorily by the Government Policy Statement on Land Transport Funding, which prioritizes funding for a six- to 10-year period. In addition to the statutory funding statement, NZTS will also be evaluated through a Transport Monitoring Indicator Framework, which is available to the public via an online interactive version. The framework provides accountability and a procedure to monitor progress towards the objectives, sector outcomes, and targets. It is also a tool for evaluating the effectiveness of the current policy and for guiding future decisions.

Fiscally-Constrained Planning

Providing transportation funding sufficient for maintaining current transportation infrastructure and putting in place capacity expansions to meet future demands is likely to be one of the most challenging public policy issues facing federal, state, and local officials in the future. Given the diversity of funding contexts at all levels of government, the most likely descriptor of future transportation funding programs is that they will be "menus" of different funding and financing strategies. In the near term, that is, over the next 20 to 25 years, the motor vehicle fuel tax will still likely be a major source, if not the major source, of funding for road projects. It also seems likely that states and metropolitan areas will continue to develop their own funding programs based on a variety of revenue sources that could allow more flexibility in using such funds for a range of projects (e.g., freight-related projects) if decision makers so chose. There has also been a growing interest in recent years in types of projects that could be jointly undertaken by both public agencies and private investors. Called public/private partnerships or P3s, these projects are

assumed to provide both public and private benefits and thus justify investment on the part of both parties (5). Given the strains on many state and local government budgets, it is likely that public/private funded projects will be an important ingredient of future investment programs.

Even with new funding sources and financing strategies, transportation funding will be limited and agencies will need to make tough decisions about the best system improvements to invest in. By identifying sustainability criteria and exploring different funding scenarios, transportation agencies and political leaders can make well-informed investment decisions (see ODOT Investment Scenarios case study for example). Life cycle cost analysis, also profiled in the case studies chapter, can also inform long-term funding priorities by quantifying not only initial costs and impacts, but also costs incurred later in a facility or program's life span.

Performance Measurement & Performance-based Planning

At the same time as transportation agencies have been applying sustainability principles and adopting sustainability practices in the U.S., there has been growing consensus that transportation plans, programs, projects and services must become more performance-driven and evaluated with measurable outcomes. Initiatives promoting performance-based decision making in transportation in the U.S include NCHRP 446: A Guidebook for Performance-Based Transportation Planning (6) and Transportation Performance Measures in Australia, Canada, Japan and New Zealand developed for the USDOT International Technology Exchange Program (7). The recently adopted surface transportation authorization policies advocated by AASHTO acknowledge the need to define an outcome-driven, performance-based approach to the plans, programs, project delivery and operational services of transportation agencies.

Performance is about the capability of generating future results (8). Various performance frameworks have been applied in different organizations over the years. Examples include the Balanced Scorecard Approach reflecting the need for including "cost" and "non cost", and "external" or "internal" measures; and the Performance Prism that adopts a stakeholder-centric view of performance (9). Often, performance is identified or equated with effectiveness and efficiency. The work of Kaplan and Norton (1992) and Keegan, Eiler, and Jones (1989) emphasize that the set of measures used by an organization has to provide a "balanced" picture of the business (10,11). It should reflect financial and non-financial measures, internal and external measures, and efficiency and effectiveness measures (9). Performance measurement theory also distinguishes among inputs, process, output and outcome measures. While the central function of any performance measurement process is to provide regular, valid data on indicators of performance outcomes, performance measurement should not be limited only to data on outcome and efficiency indicators. It should also include information that helps managers to evaluate internal processes and gain insight into the causes of outcomes.

Performance measurement should also relate the costs of the service to what the service produces. Input measures relate to the resources used to produce outputs and outcomes, such as employee time. Outputs relate to the products and services delivered; the completed products of internal activity such as the number of miles of road repaired. Outcomes, on the other hand, relate to the events, occurrences or conditions that are outside the activity or program itself and are of direct importance to the customers and the public generally (12). Because some organizations have control over outputs but not outcomes (which may be influenced by the activities of other organizations and other factors), it is important for a balanced performance measurement process to include input, output and outcome measures. NCHRP 466 cautions that performance-based planning is an

incremental process that must focus on primary strategic objectives and be clear about causality (6).

Effective performance-based planning for sustainability is dependent on two things: 1.) defining meaningful and acceptable performance measures that can gauge the results of sustainable development initiatives and practices and 2.) developing a framework for monitoring performance and then using that feedback to influence future planning efforts. Several of the case studies address these issues.

Freight Planning

Numerous studies and forecasts have shown that the fastest growing user group of the nation's transportation system is the freight sector, especially trucks, particularly due to increasing trade flows (13). Federal transportation legislation, starting with ISTEA in 1991, has encouraged the consideration of freight issues in the transportation planning process. Given the number of statewide freight plans (14,15,16), and metropolitan freight plans (17) that have been developed recently, there will likely be a growing interest in freight planning in coming years. Research has been conducted on how to undertake such planning (18) and to integrate freight considerations into the transportation planning process (19).

At the national level, FHWA's Office of Freight Management and Operations is exploring the connections between freight and land use in a new handbook. The guidebook is intended as a resource guide and handbook for use by a broad audience in state DOTs and MPOs when considering freight transportation and land use in planning processes and projects. It will identify freight-related land use issues, key considerations in land use and freight planning activities, and available tools, techniques, and strategies. Throughout the guidebook, examples and case studies will be used to show the benefits and applications of these techniques. The guidebook also examines how poor freight land use planning impacts the different aspects of sustainability, and provides examples of sustainable freight land use strategies being used by municipal agencies and MPOs. In particular, the sustainability chapter explores issues such as emissions reductions and climate change impacts, job creation and preservation, and community impacts of freight. More information about FHWA's freight planning activities and publications can be found at http://www.fhwa.dot.gov/freightplanning/.

Much of the literature on transportation-related sustainability, however, has focused on passenger travel without much attention given to freight movement. One of the few freight studies that explicitly examined freight planning from a sustainability perspective is found in London, England where different strategies were proposed to reduce environmental impacts of goods movement while enhancing economic development (20).

Climate Change Adaptation and Mitigation

Climate change is an important element of environmental sustainability, one that is gaining attention across the country. FHWA has been a leader in this area, with two notable studies completed in 2008: The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure and Gulf Coast Phase 1. The former is an assessment of the potential effects of sea level rise and increases in storm surge on transportation infrastructure in coastal states and low-lying regions on the Atlantic coast from New York to Florida. The Gulf Coast Phase 1 examined how changes in climate over the next century could affect transportation systems in the US central Gulf Coast region, and discussed ways

to account for those impacts in transportation planning. The Gulf Coast Phase 2 study will focus on Mobile, AL to develop and demonstrate tools and guidance for analyzing impacts at the local level and designing an adaptation strategy. Phase 2 will also develop a vulnerability/risk assessment model to help decision makers identify climate change vulnerabilities and systematically implement transportation facility improvements (76).

Nearly one-third of the state DOTs reported being involved in or developing a climate change initiative in a national survey conducted in 2008-2009. It is important to note that most of these initiatives were stimulated by state policies like a greenhouse gas budget or Governor's directive. Transportation Research Board Special Report 290: Potential Impacts of Climate Change on US Transportation outlines anticipated impacts of climate change on the U.S. transportation sector, discusses and prioritizes appropriate responses and assesses which data, decision support tools and adaptation strategies are needed to address climate change effectively in transportation (21). The white paper Adaptation of Transportation Infrastructure to Global Climate Change Effects: Implications for Design and Implementation examines the implications of Global Climate Change (GCC) over the lifecycle of decision making on transportation facilities and systems: planning, preliminary engineering and NEPA, project design and construction, operations and maintenance (22).

Recently, there has been a wave of state policies related to climate change, some of which are in response to regional efforts to reduce greenhouse gas (GHG) emissions. The three regional efforts are the Western Climate Initiative, the Regional Greenhouse Gas Initiative (Northeast and Mid-Atlantic states), and the Midwestern Regional Greenhouse Gas Reduction Accord. As of January 2009, 27 states had adopted greenhouse gas reduction targets either by law or by executive order (23). California was the first state to pass comprehensive legislation for greenhouse gas reduction in 2006 (following a 2005 Executive Order that set reduction targets), legislation that survived a recall vote in 2010. California is committed to a reduction of GHG emissions to 2000 levels by 2010; a reduction of GHG emissions to 1990 levels by 2020; and a reduction of GHG emissions to 80 percent below 1990 levels by 2050. Supportive legislation has since been passed to help the state achieve the goals. On September 30, 2008, Governor Schwarzenegger signed SB 375 into California law, which requires Metropolitan Planning Organizations (MPOs) to create sustainable communities strategies (SCS) to be used as roadmaps to reduce greenhouse gas emissions and requires all 18 MPOs in California to incorporate SCS into their Regional Transportation Plans.

Maryland is one of the most recent states to adopt a greenhouse gas emissions budget. The Greenhouse Gas Emissions Reduction Act, signed in May 2009, establishes an ambitious target of cutting emissions 25 percent below 2006 levels by 2020 and directs the Maryland Department of Environment to create a strategy and timeline for achieving the goal. In addition to the emissions budget, Maryland lawmakers are promoting rapid transit-oriented development, reliable local planning choices, and a clearer understanding of development impacts on the environment through the Smart, Green, and Growing legislation agenda (24).

Florida is another state that has been particularly active in legislating climate change initiatives. In response to the November 2007 Florida Energy and Climate Change Action Plan, the 2008 state legislature passed two bills with new requirements for energy efficiency, land use planning, building standards, and transportation strategies to address greenhouse gas reductions. The Plan contains additional policy recommendations for the transportation sector (including Transportation System Management, increasing transportation mode choices, and increasing freight movement efficiencies) that have

not yet been legislated.

Many of the state policies, like greenhouse gas budgets, do not directly mandate activities for the state DOT, but they do require cooperation of multiple agencies to achieve the goals. Colorado's state legislature has taken a more direct approach – legislation passed in March 2009 requires that the statewide transportation plan (prepared by Colorado DOT) address greenhouse gas emissions reduction by finding ways to serve mobility needs without expanding roadways.

Countries like the UK and New Zealand, which are viewed as sustainable transportation leaders, have strong national policies that guide planning. Similarly, the state DOTs that were most often identified by peers as leaders in sustainability (according to the survey), have mandates or strong support from state lawmakers for sustainable transportation planning. The climate change policies in California, Maryland, and Florida will undoubtedly impact the priorities of those states' DOTs.

Climate change initiatives focus mostly on mitigation; however, there is growing attention to adaptation needs. For example, Caltrans and other state agencies have sponsored a sea-level rise study to identify critical infrastructure that could be impacted. The study will help Caltrans prioritize which infrastructure to adapt and where not to locate infrastructure in the future.

Social Sustainability Assessment

Of the three major objectives of sustainability, tansportation agencies both in the US and abroad struggle most with assessing social sustainability. This may be due to difficulty in defining social sustainability or to a lack of appropriate data to conduct the analyses that provide meaningful information for decision-making. In terms of definitions, socially sustainable (urban) transportation (SSUT) has been defined as transportation that provides equitable access to opportunities, minimizes social exclusion, and improves (or does not diminish) an individual's quality of life (25). The literature seems to indicate that sustainability efforts have tended to include system performance and environmental criteria, less of economic criteria, and much less of social criteria. Social sustainability research includes three aspects: social equity, social exclusion and quality of life, with a common thread as the fair distribution of society's benefits and burdens. Equity refers to the fairness of distribution of resources based on need, which can be in conflict with total system efficiency. Exclusion is the result of spatial, temporal, financial or personal obstacles, and quality of life (more of a subjective measure) is a multidimensional construct measuring the ability to seek happiness and fulfill needs (25).

There have been several efforts to translate those definitions into social sustainability indicators. Steg and Gifford (2005) present a list of 22 quality of life indicators adapted from Poortinga et al. (26,27). The Swiss Government's Sustainable Development Initiative (28), Sustainable Seattle Coalition's community sustainability indicators, and PROSPECTS (Europe) are good sources of SSUT indicators. However, there is often difficulty in identifying appropriate data sources for desirable indicators. In this case, developing indicators requires creative use of available data. For example, several variables can be combined into a quality of life index; when considered alone the data may indicate one condition state, but when considered jointly the data may suggest trade-offs that occur. The UK experience suggests that disaggregating traditional transportation statistics by geography or socioeconomic group could be an effective method for analyzing social equity (29). Such an analysis would require census data (demographics, geopolitical

boundaries) and available transportation statistics. A Geographic Information System (GIS) could also aid in such an analysis.

Environmental Justice (EJ) and Context Sensitive Solutions (CSS) policies are the most common ways that US agencies address social equity, through consideration of the local context and an extensive public involvement process. More comprehensive assessment methodologies are needed. Health Impact Assessment (HIA) (described in detail in Chapter 5) is an example of such a method, and is starting to be used for transportation planning efforts in both the US and abroad.

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Chapter 3:

State of the Practice

Section I: US Practices in Planning for Sustainable Transportation

A survey of the state Departments of Transportation (DOTs) was conducted by Georgia Institute of Technology from Fall 2008 to Spring 2009 to characterize current activities in sustainable transportation (see questions below). The survey indicated that various state DOTs appreciate the importance of sustainability in their external and internal activities, and can point to specific initiatives, largely environment-related, that demonstrate their interest in or commitment to sustainability. Agencies are clearly focused on a range of activities with various levels of engagement in sustainability practice. Examples of planning and analysis tools to address sustainability in transportation planning include scenario planning, GIS, prioritization and performance measurement, climate action plans, health impact assessments, green rating systems, and others.

Survey Questions: Sustainability and Transportation Planning

1. What policies has your board, agency, or department head enacted regarding environmental stewardship? These could be very broad policies relating to overall agency activities, or something as specific as how roadsides are maintained. If such policies exist, what was the reason for their adoption (if known)?
2. Which units of your agency are responsible for the different initiatives? From your experience were there any barriers or difficulties encountered in implementing the initiatives?
3. Has the inclusion of environmental stewardship considerations changed the institutional structure of the organization - for example, was a new position, team, or department created?
4. Are the policies/programs coordinated with any other DOT departments or with outside agencies/local governments?
5. Are the eventual outcomes of these programs/policies measured or monitored? If so, what indicators or measures are used? How often does this measurement occur? Who receives this information within the organization? Are there any examples of where this information was actually used to change program characteristics?
6. Does your department address other aspects of sustainability in the planning process? Economic development? Land use? Quality of life or social equity? Other? Please explain.
7. Has the inclusion of these other sustainability considerations changed the institutional structure of the organization - for example, was a new position, team, or department created?
8. Are the policies/programs coordinated with any other DOT departments or with outside agencies/local governments?
9. Do these programs/policies involve measuring or monitoring sustainability? How? How often?
10. Do you know of any examples in other DOTs that are good examples of sustainable planning practices?

Each DOT has a unique package of policies or programs, but all the state DOTs address environmental planning in some way. Recently, green initiatives and climate change plans have been receiving attention across the country. In terms of economic sustainability, project prioritization methods are becoming more desirable as state DOTs attempt to maximize outcomes with relatively limited resources. The high level of prior activity in environmental (stewardship) initiatives is likely the result of federal legislative priorities in that area, although the current financial crisis may be shifting the balance towards economic initiatives. State DOTs are least active in social sustainability (beyond environmental justice policies and public involvement processes) and struggle to find appropriate performance measures to monitor social impacts. The survey also indicates that state DOTs have relatively little knowledge about peer activities addressing sustainability in transportation, but they are interested in sharing their experiences and learning from their peers. In the absence of a broad overarching sustainable development strategy, peer exchanges or other support resources such as online outreach materials could be valuable learning resources for agencies. Some level of coordination between and among state agencies would be necessary for states to address sustainability more comprehensively.

The following sections describe the state of the practice, with specific practices in each area described in more detail in Chapter 5: Case Studies. Best practices are those practices that are models for other transportation agencies and have been recognized by FHWA, AASHTO, or peer agencies.

Environmental Sustainability & Climate Change Initiatives

A majority of state DOT environmental initiatives began in response to federal requirements of the National Environmental Policy Act (NEPA) or national transportation reauthorization acts. The environmental initiatives range from roadside planting/mowing practices and wetland banks to early environmental screening and comprehensive environmental management policies. Just under half of the survey respondents reported a CSS program or approach to project development. Other environmental management best practices fall into two categories: early environmental screening and green or climate change initiatives.

State DOTs reported a wide range of green initiatives – from growing biodiesel crops and purchasing a more energy efficient vehicle fleet to greenhouse gas emissions budgets and climate action plans. Specific examples from the survey are described in Table 3-1. Climate change, an important piece of environmental sustainability, is gaining attention across the country. During the survey from 2008-2009, almost one-third of the state DOTs reported involvement with a climate change initiative. By 2011, over 35 states had climate action plans and more than ten had adaptation plans; state and regional transportation agencies typically contribute to those plans (77). Climate change initiatives possibly represent new concepts to transportation-environment planning because they are examples of comprehensive and collaborative approaches. It is important to note that most of these initiatives were stimulated by state policies (like a greenhouse gas budget) or a governor's directive. Both Vermont (VTrans) and California (Caltrans) have released climate change plans, and Oregon DOT collaborated on the Oregon Climate Change Adaptation Framework, which was released in December 2010 and assesses climate impacts to transportation and other critical infrastructure.

Table 3-1. Summary of Environmental Sustainability Best Practices

DOT	Practice	Description
Oregon	Context Sensitive and Sustainable Solutions	Decision-making framework that combines context-sensitive design with sustainability principles (www.oregon.gov/ODOT/HWY/OTIA/bridge_delivery.shtml)
Delaware & Tennessee	GIS-based environmental screening	Statewide GIS data used to identify environmental issues during the planning process; requires GIS data from multiple state, regional, and local agencies
Florida	Efficient Transportation Decision-making	Process to anticipate environmental problems early on through partnership with resource agencies, public involvement, and GIS-based environmental assessment (http://etdmpub.fla-etat.org/est/)
Pennsylvania	Linking Planning and NEPA	Training program to educate employees on linkages and overlaps between planning and NEPA in order to streamline both processes (www.environment.fhwa.dot.gov/integ/int_pennsylvania.asp)

DOT	Practice	Description
Vermont	Energy and Climate Change Action Plan	Preventative measures to address impacts of air quality and climate change, including both mitigation and adaptation approaches; involves coordination with local governments, state agencies, and neighboring states (www.aot.state.vt.us/Planning/Documents/Planning/VTransClimateActionPlanfinal1.pdf)
California	Climate Action Program	Active climate change mitigation and adaptation measures in response to state legislation; includes greenhouse gas reduction strategies, sea-level rise assessment and habitat-connectivity study (www.dot.ca.gov/climateaction.htm)
Oregon	Climate Change Mitigation Policies and Practices	Efforts to address climate change through both internal and external practices that address vehicle miles traveled and system efficiencies; formed a Climate Change Executive Group and Climate Change Technical Advisory Committee to establish priorities and guide ODOT activities; recognize importance of land use planning and multi-modal planning for mitigation (www.oregon.gov/ODOT/SUS/index.shtml)
Illinois	Sustainability Program	Initiatives to improve agency's internal sustainability (energy efficiency, emissions reduction, recycling) and be a model for local governments

Performance Measurement

Performance measurement is a tool for transportation agencies to monitor and assess progress toward sustainability. Approximately 60% of the DOTs reported that they use performance measures or indicators related to the environment, economy, and/or quality of life. However, many of the DOTs lacked a formal or comprehensive system for tracking these measures. Notably, the Texas DOT (TxDOT) recently worked with the Texas Transportation Institute on a project to develop sustainability indicators for the agency's strategic plan (the technical report was published in April 2009). The project resulted in 13 sustainable transportation performance measures that relate back to goals in TxDOT's strategic plan. For example, for TxDOT's "improve air quality" goal, the related sustainability objective is to reduce adverse human health impacts, which is related to the following performance measures: daily NOx, CO, and VOC emissions per mile of roadway. In addition to the performance measures framework, the technical report provides TxDOT with methodologies for evaluating the measures using readily available data inputs, and defines a process for benchmarking, indexing, and monitoring the measures. A few case studies demonstrate how the measures can be applied to rural, urban, and suburban contexts (30). Several other state DOTs provide good examples of performance measurement, with Minnesota DOT's system being cited most often in the survey. See Table 3-2 for these examples.

Table 3-2. Summary of Performance Measurement Frameworks and Reporting Best Practices

DOT	Practice	Description
Texas	Sustainable Transportation Performance Measures	Framework for sustainability measures that correspond to goals in TxDOT's strategic plan; current selection of measures was limited by data availability (tti.tamu.edu/documents/0-5541-1.pdf)
Minnesota	Performance-based Planning & Programming	Framework using clear policy priorities, performance trend data, and performance forecasting to guide investment decisions; measures cover both internal and external activities (www.dot.state.mn.us/measures/)
Washington State	Gray Notebook	Quarterly report of goals and measures organized around WSDOT's five legislative and strategic policy goals (safety, preservation, mobility/congestion relief, environment, and stewardship) and a "Performance Dashboard" of key indicators; transparency and organized presentation make it useful for internal tracking and external accountability (public review) (www.wsdot.wa.gov/accountability/graynotebook/default.htm)
Iowa	Results Iowa	Annual report and online monitoring system that outlines performance goals and measures, and assesses which targets have been met; measures used to adjust allocation of resources and identify investments in priority corridors (www.resultsiowa.org/transport.html)
Missouri	Tracker	Quarterly report of measures for eighteen outcome areas covering environmental responsibility and economic development since 2005; an additional goal added in 2009 to track impacts of stimulus funding (www.modot.org/about/general_info/Tracker.htm)
California	State and Regional Measures	Reports on performance goals and measures at both the regional (Blueprint Planning reports) and state level (annual reporting on 9 performance outcomes from the California Transportation Plan) (http://calblueprint.dot.ca.gov/0506_grant_info_files/SACOG_Performance_Measures.pdf and www.dot.ca.gov/perf/)

In addition to tracking performance, sustainability-related indicators were cited as an important means for assessing and prioritizing transportation projects. Approximately 20% of the DOTs were using or developing indicators for project prioritization. For example, Caltrans uses the concept of the System Management Pyramid (SMP) is to guide project prioritization and influence investment decisions (see Figure 3-1). The base of the pyramid is system monitoring and evaluation, which is achieved by collecting and tracking transportation system performance measures. Caltrans collects performance measures related to safety and security, system preservation, mobility/access, reliability, and customer satisfaction at the state level. The measures are used to identify areas of deficiency (or opportunities for improvement) and the pyramid is then used to assess potential solutions. In addition to being used during development of the statewide transportation plan and improvement programs, the SMP has been used to prioritize projects for economic stimulus funding. Additional examples of indicator use are provided in the discussion of economic and financial sustainability (on page 29). Indicators are also commonly used to compare and assess transportation and land use scenarios. Indicator frameworks for project prioritization provide an opportunity to develop robust sustainability measurement systems, though it must be noted that most indicator frameworks for state DOTs are not explicitly linked to sustainability goals.

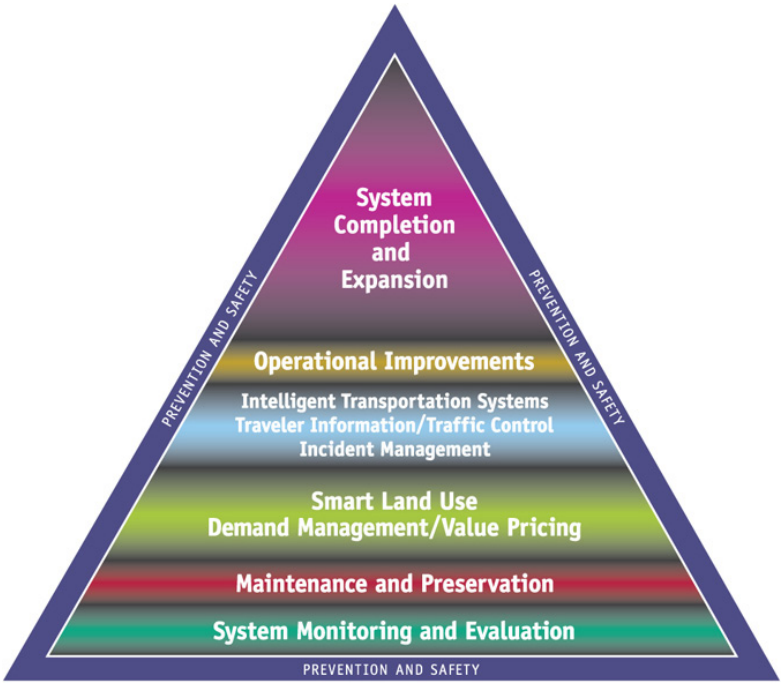

Figure 3-1. Caltrans' System Management Pyramid
(Source: http://www.dot.ca.gov/hq/traffops/sysmgtpl/)

Sustainability Plan or Program

As of 2010, only five state DOTs and the District of Columbia DOT had a formal sustainability plan or program (Table 3-3). Sustainability plans and programs are important because they provide a comprehensive and coordinated way to address sustainable transportation within the agency and across complementary state agencies. International best practices were also examined; most notably, the New Zealand Ministry of Transport's sustainability-centered long-term plan. Oregon DOT has released the first two volumes of its Sustainability Plan, which is the US example most similar to New Zealand's plan. London's strategic freight plan was also developed with a sustainability focus. It is very clear from these efforts that the accomplishment of more sustainable transportation outcomes must be a function of a comprehensive multi-faceted approach. New Zealand and London's plans are described in more detail in Chapter 5.

Table 3-3. Summary of Sustainability Plan/Program Best Practices

DOT	Practice	Descriptions
Oregon	Sustainability Plan	Three volume plan that will outline goals, actions, and performance measures for internal actions and external system management to achieve a sustainable transportation system; Volume 1 (defining sustainability) released in January 2009 and Volume 2 (internal operations) released in Fall 2010; Volume 3 (managing statewide transportation network) under review (www.oregon.gov/ODOT/SUS/index.shtml)
Pennsylvania	Smart Transportation	Partnering with other agencies, states, and local communities to make financially, environmentally, and socially sustainable decisions; includes a public education campaign and a handbook co-authored by New Jersey DOT (www.smart-transportation.com)

DOT	Practice	Descriptions
Massachusetts	Sustainable Development Principles, Commonwealth Capital Review, Mobility Partnership	Statewide sustainable development principles adopted to guide policies, programs, and infrastructure investment decisions; partnering to coordinate transportation service planning and delivery
California	Smart Mobility Framework	Pilot project with EPA to create a sustainability assessment framework for transportation policy, planning, and programming; currently being tested for corridor analyses but will be used to assess regional and state efforts as well (www.dot.ca.gov/hq/tpp/offices/ocp/smf.html)
Washington State	Sustainability Plan and Progress Report	Annual plan update and progress report on sustainability targets and emerging issues (www.wsdot.wa.gov/planning/)
Washington, D.C.	Sustainability Plan	Collaborative effort of all DOT units that describes eight priority areas for promoting sustainability; includes recommended actions, measures and targets for each priority area (ddot.dc.gov/DC/DDOT/Projects+and+Planning/Environment/Sustainability+Plan)

Transportation and Land Use Coordination

Due to the local control of land use decisions, state DOTs have limited opportunities to influence land use policy. For the most part, state DOTs influence land use through access management policies, basically limiting the number of access points to state-supported roadways in order to manage growth. Twenty-two of the surveyed DOTs reported that they address land use coordination and one-third of them reported using access management as the primary tool. Those states (seven respondents) with Smart Growth legislation or comprehensive planning requirements are better able to plan for land use impacts and respond to changes in land use. A number of state DOTs are engaging in coordinated transportation and land use planning in various ways (Table 3-4). Each initiative involves coordination with other state-level agencies and/or local governments.

Table 3-4. Summary of Coordinated Transportation-Land Use Best Practices

DOT	Practice	Description
Montana	Systems Impact Action Process (SIAP)	Transportation Impact Analysis tool and coordinated development review process for determining impacts and required mitigation (www.mdt.mt.gov/publications/docs/brochures/siap_guide.pdf)
Pennsylvania	Land Use and Transportation for Economic Development (LUTED)	State and regional agencies coordinate efforts for land use, transportation, economic development, and conservation to make effective investment decisions; DOT's Sound Land Use Implementation Plan is updated annually (www.newpa.com/get-local-gov-support/community-planning/luted-initiative/index.aspx and ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20572.pdf)

DOT	Practice	Description
California	Regional Blueprint Planning Program	Grant program for collaborative regional visioning and scenario planning that integrates transportation, land use, housing needs, resource protection, and other issues; communities shape their Blueprints process through selection of performance goals (http://calblueprint.dot.ca.gov/)
New Jersey	NJ Future in Transportation (NJFIT)	Effort coordinated with NJ's Office of Smart Growth to emphasize re-investment and transformation of existing transportation infrastructure; produced nationally recognized programs including Transit Villages and Mobility and Community Form (www.state.nj.us/transportation/works/njfit/)
New York State	Smart Planning	Smart Growth educational and training programs and planning assistance for local and regional transportation agencies; website to facilitate communication (www.nysdot.gov/programs/smart-planning)
North Carolina	NC Interagency Leadership Team (NCILT)	Coordinate transportation and land use planning efforts among several state and federal agencies; initiatives include a statewide action plan and development of a comprehensive shared GIS database (www.ncdot.org/programs/environment/development/interagency/ncilt/goals/)

Green Transportation Ratings

State DOTs are currently leading or contributing to several initiatives to implement green standards for transportation facilities. Green infrastructure is an important lever for promoting sustainability. For the most part, the state DOTs have developed rating systems modeled after the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system for buildings. The LEED system, while not required, has led to marked improvements in the sustainability of buildings. LEED certification has become a great marketing tool for new developments due to positive public perception. Green standards and certifications for transportation projects could likewise stimulate innovative and sustainable design and improve the carbon footprint and image of the transportation industry. Table 3-5 describes some of the rating systems that were active or in-development by 2011. In addition to the tools listed in the table, FHWA has developed a sustainable highways self-evaluation tool (refer to page 3 for more information). With all of the options out there, it is not important which tool is chosen but that a tool is being used and customized to the agency.

Table 3-5. Summary of Green Transportation Standards and Ratings

Developer	Practice	Description
New York State DOT	GreenLITES (Leadership In Transportation and Environmental Sustainability)	First completed rating system; applied internally to DOT projects to recognize sustainable practices, encourage innovation, measure performance, and identify areas for improvement; certifications and awards will be announced annually (www.nysdot.gov/programs/greenlites)

Developer	Practice	Description
U of Washington, CH2M Hill, WSDOT	Greenroads	Sustainability rating system for highways that includes 76 credits in 7 categories, including 11 required credits; draft version being tested and calibrated; roadway developers will be able to apply for official certification or use the system for guidance (www.greenroads.us/)
Public-private initiative with support from EPA, FHWA, Maryland DOT (MDSHA)	Green Highways Partnership (GHP)	Voluntary partnership to share information and provide guidance for developing more sustainable roadways (www.greenhighways.org/index.cfm)
University of Wisconsin with Wisconsin DOT	BE^2ST rating system	Approach based on triple bottom line that uses qualitative measures to screen road projects and then rates a project with quantitative measures. Incorporates LCA (environmental) and LCCA (economic).
Lochner Engineering	Sustainable Transportation Environmental Engineering and Design (STEED)	Checklist for sustainable highway/roadway projects that should be applied during planning, environmental assessment, design, and construction phases; able to track how projects change (www.hwlochner.com/Company/Pages/Steed.aspx)
Public/private team from Oregon and Washington	Sustainable Transportation Access Rating System (STARS)	Rating system for transportation projects, plans, and employer programs that is under development

Economic or Financial Sustainability

In terms of economic sustainability, there is prevailing concern about the future of transportation funding, and many state DOTs are exploring ways to prioritize transportation investments to better meet user needs and maintain the system. The financial crisis confronting infrastructure may overshadow a number of other critical issues. Almost 60% of state DOTs referenced the importance of funding and prioritization of financial resources. One DOT explicitly stated that funding is the key issue for future study. To aid in assessing and prioritizing transportation projects, several DOTs are using scenarios and/or indicators to examine the type and magnitude of impacts (see Table 3-6). Performance indicators offer a relatively objective means for comparing transportation projects or investment packages and determining how they will contribute to the DOT's vision and goals. Beyond performance measurement, one of the fundamental challenges this century is defining a sustainable funding mechanism for transportation, one that would likely involve tax or user-cost financing and public/private partnerships.

Table 3-6. Summary of Economic and Financial Sustainability Best Practices

DOT	Practice	Description
Montana	Performance Programming Process (P3)	Decision process for funding allocations based on asset management principles, scenario planning, and strategic goals (www.mdt.mt.gov/publications/docs/brochures/tranplanp3.pdf and www.trb.org/conferences/2007/PM/1A_Sandy_Straehl.pdf)
Oregon	Investment Scenarios	Oregon Transportation Plan assesses seven policy scenarios and three investment scenarios to determine system performance outcomes of different levels/types of investment (www.oregon.gov/ODOT/TD/TP/docs/ortransplanupdate/2007/OTPvol1.pdf)
Illinois	Program Menu	Develops funding packages based on different emphases (eg. system preservation or capacity for economic development) and use iterative process to allocate all available funding and meet statewide transportation needs
Montana	Highway Economic Assessment Tool (HEAT)	Enhanced benefit-cost analysis tool for projects that accounts for system impacts at state, corridor, and project level; considers traditional mobility measures in addition to economic and resource impacts; tool is customizable to each state's goals and data availability (www.mdt.mt.gov/research/reconfigstdy/ and www.camsys.com/tp_planpro_heat.htm)
Illinois	Lifecycle Costing	Process to assess present and future roadway condition and prioritize improvement projects; based on a facility's cost over its lifetime rather than just the upfront capital costs

Challenges in addressing sustainability

One of the most important challenges faced is the necessity of institutional change for developing and implementing effective sustainable transportation policies and programs. Over 60 percent of the DOTs reported that a new team, position, department, or arrangement resulted from incorporation of a new environmental sustainability initiative. A few of these changes (usually reorganization or combination of departments) occurred in the 1970s as a result of federal legislation, but many have occurred within the last decade. Common institutional changes include:

- Forming new teams/interdisciplinary groups for special initiatives such as climate change or "green" programs;
- Bringing environmental specialists and planners together under one division; or
- Creating a new office or staff positions to manage large-scale programs.

Another commonly cited issue was prioritizing funds for new initiatives when existing programs are already competing for limited funds. The issue is compounded by concern (usually unfounded in the long term) that green design or CSD will add costs to projects. Yet another issue is institutional inertia, which relates to the arduous task of getting the different DOT divisions on-board with new or innovative policies. Similarly, local governments are often resistant to new policies, particularly ones that they perceive as a threat to their power. Overcoming the internal or external resistance often takes leadership, coordination, education and time. There are unique challenges for large, decentralized

DOTs like Texas and California, which must try to coordinate activities across all districts while still maintaining sufficient flexibility to address the districts' different priorities. For example, it may be difficult to address the issues of both rural and urban districts with just one policy. The case studies (Chapter 5) provide examples of how transportation agencies have started to address these challenges.

Section II: International practices and emerging practices in planning for sustainable transportation

Sustainability Policies and Research Strategies

Sustainable transportation initiatives at the sub-national or local level are strongly influenced by national policies and regulations. As stated earlier, the US does not have overarching policy guidance for sustainable transportation. Europe and New Zealand offer examples of what a national policy could look like and how it could influence agency and research and development plans at sub-national levels. The New Zealand and the Randstad (i.e., the Netherlands) examples are also very relevant to state or regional policymaking because of similar geographical scales and relationships among transportation agencies at different levels.

New Zealand

New Zealand has taken the lead in developing a coordinated national policy for sustainability. The New Zealand Transport Strategy (NZTS) 2008 establishes a set of targets to be achieved in transportation over the next 30 years. NZTS 2008 was strongly influenced by climate change and energy policy. Sustainability is explicitly part of their future vision: "people and freight in New Zealand will have access to an affordable, integrated, safe, responsive and sustainable transport system." The plan's targets reflect the stated vision and include halving per capita greenhouse gas emissions from domestic transport by 2040, increasing rail's share of freight to 25 percent of tonne-kilometers by 2040, and widely using electric vehicles. While setting targets is not necessarily unique for transportation plans, NZTS 2008 is set apart because the targets will be statutorily enforced through the Government Policy Statement on Land Transport Funding, which establishes short-term system goals that will be achieved by prioritizing funding over the next six to 10 years. In addition to the statutory funding statement, NZTS will also be evaluated through a Transport Monitoring Indicator Framework, which is being made available to the public via an online interactive version. The framework provides a procedure to monitor progress towards the objectives, sector outcomes, and targets in the Transport Strategy and Government Policy Statement. It provides a tool for evaluating the effectiveness of the current policy and for guiding future decisions. Last but not least, it also provides accountability (31).

European Union

The European Union is also recognized as a leader in coordinating sustainability at a high level through the Common Transport Policy (CTP) and the Framework Program (FMP). The goal of a "common" transport strategy is to remove barriers to free movement of goods and people throughout the EU by promoting a balanced network and sustainable development patterns. The CTP establishes targets and goals for transportation for the EU as a whole (which are translated down to the member states), but like the United States the goals are not mandatory. The CTP was established in 1992 with the express goal of using transportation to balance economic development. It has evolved over time to reflect an increasing commitment to sustainable transportation and a broader focus. In 2001, policy directives were released as a white paper called "Keep Europe Moving - Sustainable mobility for our continent." The 2001 policy emphasized mode shifts to more sustainable alternatives like transit, biking, and walking. In 2007, the European Commission released a "Green Paper: Towards a new culture for urban mobility" that reflects a commitment to sustainable energy and modes for transportation. Green papers (discussion papers on a specific subject area) and White papers (proposals for EU community actions on a particular topic) are a primary means of communication between the EC and member states (32). The FMP establishes the priorities and funding for the European Union's research, technological development and demonstration activities over a five year period, and is designed to complement the EU's priorities as reflected in the CTP (33). The FMP is carried out by government offices, universities, and private consultants in the Member States. In addition to the EU's efforts, individual member states, like Germany, Sweden and the Netherlands, have been recognized for innovative approaches to sustainable transportation (34).

The Randstad

The Randstad, an area consisting of the Dutch cities of Amsterdam, Rotterdam, The Hague and Utrecht, has a population of approximately 7.5 million. When combined with contiguous urban areas, the Randstad is one of the largest metropolitan areas in Europe. The Dutch government has identified an aggressive sustainability initiative called the Urgent Randstad Programme and the Randstad 2040 Strategic Agenda consisting of three major themes: Accessibility and economic dynamics; Climate-proof delta; and Quality of life and a good climate for residence, business and leisure.

From a research perspective, the Minister of Transport, Public Works and Water Management, the Minister of Housing, Spatial Planning and the Environment, and the Minister of Economic Affairs have developed a long-term research program called "Sustainable Accessibility of the Randstad (2008-2040)". The themes established for funding research in this program include:

- Limiting home-to-work commute times, particularly between the main cities;
- Increasing the reliability of travel times;
- Soundness of infrastructure networks that can cope with unexpected events (e.g. accidents and weather conditions);
- Increasing the economic vitality of the Randstad;
- Strengthening the international competitive position of the Randstad; and
- Sustainability of the transport and infrastructure system, partly in view of climate change and energy transition.

Relevant sustainability perspectives in the context of the Randstad research program

include: connecting at different scale levels, the synergy between urban development and infrastructural networks, and the interconnectivity of infrastructure networks. The research program will further address questions on the region's sustainability. Which gaps in our knowledge appear if we reason from the future perspective being outlined? And how can these gaps be filled? How exactly is the accessibility of the Randstad defined and quantified from a network perspective? To what extent and in what ways are the internal and external accessibility of the Randstad affected by climate change, the new water level and the energy transition? Like the EU's program, the Randstad's program integrates research and planning at multiple scales and across multiple sectors.

Spatial Analysis and Planning

Spatial planning is defined as a "self-conscious collective effort to re-imagine a city, urban region or wider territory and to translate the result into priorities for area investment, conservation measures, strategic infrastructure investments and principles of land use regulation" (35). The purpose of spatial analysis is essentially to explore potential development pattern scenarios with respect to economic development and smart growth principles. In particular, it is concerned with physical places (and their attributes) and the networks that connect them. Like scenario-building, it is a tool for informing policy and regulatory decisions. Further, it can help coordinate public policies among multiple government units and enhance regional competitive advantage by developing and leveraging a "collective asset base" (35). Spatial planning can be used to promote sustainable development by balancing environmental preservation, economic feasibility, and social equity. In terms of sustainable transportation, development scenarios require or enable certain transport projects. Spatial planning ties together the way that space is planned and used (where development happens and its form) and how people/goods can access the facilities and services that they need (36).

The general components of a spatial analysis include assessing existing conditions; evaluating internal and external relationships (linkages); performing a land suitability analysis; performing demographic projections by cohort (age, sex, income class, et cetera); investigating future development scenarios; and creating visualizations of potential patterns. A Spatial Plan is different from a traditional land use plan because it emphasizes the coordination of spatial impacts from multiple decision makers. It results in an identification of key areas of change and critical issues with the spatial development, and defines clear goals for outcomes in multiple areas. Further, spatial planning can promote mutual learning and information sharing in a collaborative, iterative political process. Unlike land use plans, the generation of scenarios is guided by an understanding of spatial development trends, market demands and needs, and environmental, economic, and social impacts. By working within a collaborative environment, stakeholders from different sectors (local government, transportation agencies, businesses, et cetera) can build ownership of the strategy and develop joint mechanisms for implementation (37).

Spatial analysis and planning have been implemented in Europe for several decades, but have only recently been discussed in the United States. The European Commission's commitment to spatial planning is embodied in the policy document European Spatial Development Perspective: Towards Balanced and Sustainable Development of the Territory of the European Union, which was agreed upon at the "Informal Council of Ministers responsible for Spatial Planning" in Potsdam (May 1999). The Netherlands is an example of spatial planning's deep roots. The Dutch have produced national spatial planning policy documents since 1960, and the concepts have influenced national, provincial

and local policy. In January 2001, the government approved the Fifth National Policy Document on Spatial Planning 2000-2020, which established a new spatial development approach based on criteria for "spatial quality". The criteria are spatial diversity, economic and social functionalities, cultural diversity, social equality, sustainability, attractiveness and human scale. The criteria are intended to be guiding principles for sub-national plans, investment programs, and regulations. The document also contains four spatial frameworks to conceptualize future development scenarios:

- a transnational policy perspective, emphasizing cross-border linkages and policies;
- the city and the country, differentiating between appropriate urban and rural development;
- urban networks, promoting integrated groups of cities; and
- going with the flow, or adopting an ecological-based framework centered on water (35).

Sustainability Footprint

Wackernagel and Rees developed the ecological footprint in 1996 as an environmental accounting tool. Since then, there have been a growing number of applications of the ecological footprint concept in infrastructure decision-making. For example, the ecological footprint has been measured for a county-level transportation network in current and future time periods (38) and applied to assess the sustainability of ports (39), building construction (40), and alternative fuels which are part of broader infrastructure systems (41). Footprint analysis has also been applied at the planning level to assess highway systems for their progress toward sustainability (42), and at the policy level as in the use of ecological footprint to explore alternative policy scenarios in a city-region in Ireland (43).

Figure 3-2 presents a simplified depiction of the sustainability footprint concept, developed and applied to evaluate the Atlanta Metro and Chicago Area highway systems (42). The sustainability footprint is defined as the rate of change of system performance as a function of the environmental costs associated with attaining that level of system performance (e.g., the costs can be measured as the consumption of natural resources and generation of wastes).

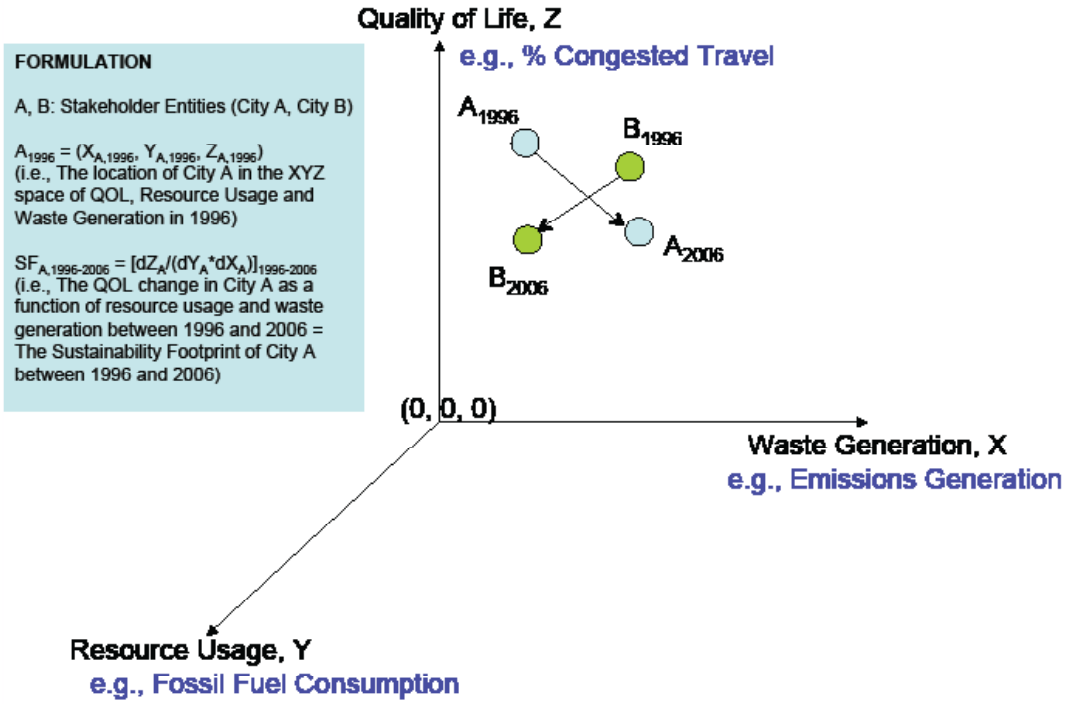

Figure 3-2. Visual depiction of Sustainability Footprint method (Source: Amekudzi et al. 2009)

The model was applied to compare the relative progress of the Atlanta Metro and Chicago Area highway systems toward sustainability in the 1996 to 2006 period. The application used QOL as the system performance measure. QOL was measured as a reduction in congested travel during this period. These reductions were then compared with fossil fuel consumption and emissions generation of the respective highway systems in the same period to determine which metro area system was offering a higher QOL to system users at a lower expense to the environment (i.e., with lower fuel consumption and emissions generation). A higher QOL increase with lower fuel usage and emissions indicates more progress toward sustainability. Different measures can be used in the Sustainability Footprint to capture the most relevant issues to the users of any particular system(s) under consideration.

Multi-Criteria Evaluation of Plan and Project Alternatives

In contrast to single objective decision-making methods, such as cost-benefit analysis, Multi-Criteria Decision Making (MCDM) tools can take into consideration a wide range of different criteria simultaneously, making the tool appropriate for sustainability evaluation. There are several applications of multi-criteria methods for alternatives analysis in planning and project development (62,72,73). Multi-Criteria decision making is especially useful when making preference-based decisions over alternatives that have multiple, usually conflicting attribute (74). Because of the multi-dimensional nature of sustainability (i.e., involving system performance, economic, environmental and social decision criteria), multi-criteria methods are well suited to evaluating competing alternatives for sustainability. Essentially, when a multi-criteria approach is applied to evaluate multiple alternatives, each alternative is evaluated across several criteria, e.g., mobility, safety, cost of transportation, NOx exposure, etc. The total value of these criteria is determined, either through a weighted sum, weighted product or other method. For each alternative, scores and weights are assigned for each criterion. The scores reflect how well the particular alternative is faring with respect to a decision criterion, e.g., economic sustainability, and the weight reflects the relative importance of the decision criterion. For example, Jeon et al., (2010) evaluated three land use-transportation plan alternatives or scenarios in the Atlanta Metro Region to determine the relative value of each alternative based on functional system performance, environmental impact, economic impact and social impact. Performance measures were developed for each of the criteria. The performance measures were based on the regional transportation goals of the Metro Region: (1) improving accessibility and mobility; (2) maintaining and improving system performance and preservation; (3) protecting and improving environment and quality of life; and (4) increasing safety and security. Examples of performance measures used for transportation system effectiveness were the average freeway speed, and average vehicle miles traveled per capita. Similarly, environmental sustainability indicators included daily emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx), two precursors for ozone. Social equity was captured by equity of exposure to emissions. Each of the land use/transportation alternatives was scored on each of these performance measures, the measures were normalized, weighted and aggregated to develop an overall sustainability index (62). This process is explained in more detail in Case Study 9.

Since the measures can also be aggregated for each sustainability dimension, e.g., economic, environmental, social sustainability or system performance, the analysis results could also be evaluated for tradeoffs among these four dimensions, allowing the analyst to distinguish among dominant and non-dominant alternatives. A tool, the Sustainability Diamond Visualization Tool, was developed to help with visualizing trade-offs and thus the relative effectiveness of each plan alternative from the viewpoint of each evaluation

criterion. The tool is described in more detail and displayed in Case Study 9, but in general it shows, for each plan alternative, four indices related to each evaluation dimension: system performance, environmental sustainability, economic sustainability and social sustainability, and an overall comprehensive sustainability index. Using this tool, one can compare the relative sustainability of competing plans as well as evaluate the tradeoffs among these plans. Examining such tradeoffs can facilitate with determining superior alternatives to promote sustainability in the region.

Strategic Sustainability Assessment

Over time, the EU has established progressively strict requirements for environmental sustainability assessment in transportation. The 1993 Treaty on the European Union (EU) requires that "environmental protection requirements be integrated into the definition and implementation of other Community policies." Based on a later EU directive, Environmental Impact Assessment (EIA) is a prerequisite for transportation infrastructure projects. Most recently, Guidelines for Trans-European transport networks (TENs) required that the European Commission develop a methodology and tools for strategic environmental assessment (SEA). SEA is defined as "the formalized, systematic, and comprehensive process of evaluating environmental impacts of a policy, plan or program and its alternatives, including the preparation of a written report on the findings of that evaluation and using the findings in publicly accountable decision making" (44). SEA essentially expands upon EIA; it combines cost-benefit analysis (CBA) or multi-criteria analysis (MCA) with environmental goals, public participation, and impact prediction models (45). The general process for SEA begins with a screening process to determine whether such an analysis is necessary. Once the need for SEA is established, the scoping process begins. Scoping involves identifying the impacts to be evaluated (based on environmental objectives), selecting methods and defining terms, and establishing parameters such as the time horizon, alternatives, and geographical scale.

The next step is the multi-part impact assessment and evaluation, which can be accomplished with either a forecasting or backcasting approach. Guhnemann and Rothengatter (1999) define forecasting as working forward from proposed projects or policies to predict the impacts and end state (46). A backcasting approach to SEA would involve:

1. Identifying levels of environmental impacts that lead to sustainable development;
2. Defining sets of policy tools that would achieve the safe levels and predicting related impacts; and
3. Choosing the policy program that maximizes societal welfare subject to environmental constraint.

A backcasting approach is deemed appropriate when the planning time horizon is long because forecasting would lead to considerable uncertainty in the impacts and risks. The final step in SEA is incorporation of the impact analysis into decision-making. A public involvement process or a formal policy may provide the necessary oversight to ensure that SEA is considered. The SEA methodology can be applied at multiple scales. At the continental level it was applied in the project "Bottlenecks in the European Infrastructure" for the European Center for Infrastructure Studies. The purpose of the project was to identify major bottlenecks to determine investment priorities. At the state (national) level, the German Environmental Agency developed a methodology to assess a regional transportation plan based on environmental considerations (46).

Despite the advancements provided by SEA, there are certain criticisms. First, using CBA and MCA assumes that criteria are independent of each other and that the impacts are unidirectional. For example, this could translate as, "transportation impacts the environment but the converse is not true" (when, in fact, it is). Second, exogenous ("forgotten") variables are not accounted for even though they can have substantial impact. Finally, while SEA is helpful for choosing among project alternatives it is still not sufficient for assessing long-term, multi-step programs (45).

A Strategic Sustainability Analysis (SSA) is capable of addressing the criticisms of SEA and expands on the SEA concept to integrate economic and social implications into transportation planning. The term SSA was first coined in 1999 at a joint meeting of Organization for Economic Cooperation and Development (OECD) and the European Conference of Ministers of Transport (ECMT). SSA is a methodology for analyzing complex transportation decisions a.) with long-term time horizons, b.) interlinked with environmental, economic, and social systems, and c.) with a spatial scope above the project-level. Schade and Rothengatter insist that traditional transportation assessment methodologies are incapable of accounting for the complex system within which sustainable transportation decisions are made (45). There are two requirements for SSA: Integration and Pathfinding. Integration involves 1.) integrating real systems into one model and 2.) integrating impact prediction and impact assessment steps into the same or interlinked model. Integration allows for an iterative process of policy refinement. Pathfinding has two additional requirements. First, long-term policies should be driven by a vision and have identifiable goals. Second, the method should be capable of showing or investigating development paths from future vision to current situations (or backcasting). SSA is characterized as a dynamic, quantitative, and consistent methodology. Specifically, it is

- "Dynamic" because it allows for stepwise introduction of policies and policy changes,
- "Quantitative" because it creates operable models, and
- "Consistent" because baselines for the economic, social, and environmental parts are based on a common set of assumptions.

Schade and Rothengatter identify two model-based approaches for SSA: the Economic Assessment of Sustainability Policies of Transport (ESCOT) model and the Assessment of Transport Strategies (ASTRA) model (45). The ESCOT model was developed by Germany as part of OECD's Environmentally Sustainable Transport (EST) project. ESCOT is a system dynamics model that integrates the five sub-models: macroeconomics, regional economics, transport, environment, and policy implementation. The user can manipulate thirteen policy measures (technical or behavioral in nature) and compare a business-as-usual scenario to desirable future scenarios (47). ASTRA was developed as part of the EU's 4th Framework Program to analyze long-term impacts of the EU's common transport strategy. It is a system dynamics model with four submodels: macroeconomics, environment, regional economics and land use, and transport. Relationships between models and internal feedback loops are integrated into one model platform. Policy packages can be assessed individually or compared against a base scenario. ASTRA can be operated in either a forecasting or backcasting mode and has the capability of using appraisal methods (like CBA or MCA) to compare alternative scenarios (48). ESCOT and ASTRA leave out one aspect of a comprehensive SSA: local impacts. Schade and Rothengatter suggest that this gap could be overcome by incorporating GIS analysis into the methodology.

Scenario Planning by Backcasting

Scenario studies have been used by different industries in the United States since the 1950s. The methodology was advanced by the Rand Corporation under the leadership of Herman Kahn for the federal government to study scenarios under which nuclear war could begin. In the 1970s Shell Oil popularized scenario planning as a business tool to predict how consumers and countries would react to an oil shortage and then prepare for it (49,50). An early definition of scenarios calls them "hypothetical sequences of events for the purpose of focusing attention on causal processes and decision points" (51).

Modern scenario planning offers a method for citizens, government officials and other stakeholders to visualize and clearly understand potential trade-offs and interactions that occur amongst transportation and the social, environmental, and economic development resulting from growth. The FHWA views scenario planning as a way to enhance traditional modeling and assessment methods and improve transportation decision-making. "Scenarios are stories about future conditions that convey a range of possible outcomes" (52). Scenario planning allows a region to realistically evaluate a wider variety of potential futures and determine what the community wants the future to look like.

There are two types of scenarios: projective and prospective (49). A projective scenario starts from the current situation and extrapolates current (or highly probable) trends to produce future images. A prospective scenario on the other hand starts from a possible or desirable future situation and works backward to the present situation. Creating projective scenarios is forecasting (the predominant method in transportation planning) whereas creating prospective scenarios is backcasting. A main criticism of forecasts is their susceptibility to error due to uncertainty about future trends, particularly when the time horizon is long (25 years or more). However, improving the ability to accurately reflect past trends is a standard procedure in model calibration. The term "backcasting" was coined by Robinson (1982) and defined as "'working backwards' from a particular future end-point to the present to determine what policy measures would be required to reach that future." It is distinguished from other methods because it is "concern[ed], not with likely energy futures, but with how desirable futures can be attained" (53). Figure 3-3 shows a schematic of how a backcasting process works. Backcasting is growing in popularity in Europe as a methodology to investigate sustainable transportation scenarios (34,46,49).

Specific examples of backcasting applications to address sustainable transportation issues (namely climate change) include OECD's EST study (49), the European Parliament's scenario development for long-distance transportation (54), and Visioning and Backcasting for Transport Policy (VIBAT) studies in the UK and India (55,56). These examples employ backcasting based on expert panel assumptions. However, it is possible to apply a participatory model to the development of transportation scenarios, particularly at the local level. "Interactive backcasting" describes backcasting as a recipe rather than a tool because it should enable "problem structuring rather than problem solving" (57). Based on this philosophy, interactive backcasting employs a mixture of methods (both quantitative and qualitative) to generate scenarios and explore pathways. To distinguish interactive backcasting from traditional backcasting, the approach places more emphasis on defining the future image than on analyzing how that future could be achieved. Interactive backcasting approaches have been developed in both Canada and the Netherlands for climate change projects (57).

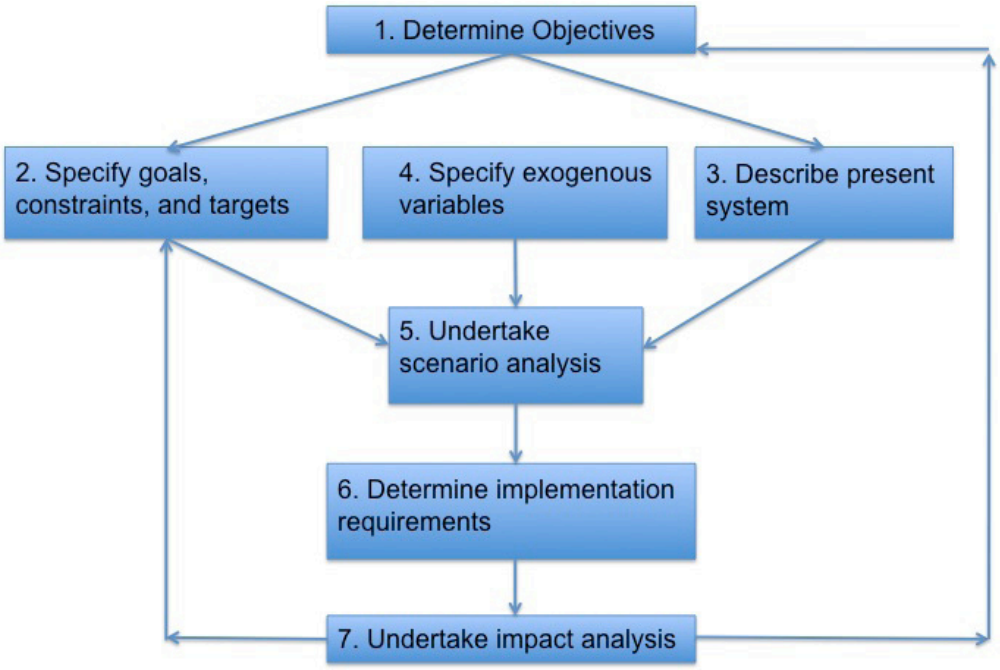

Figure 3-3. Schematic of a generic backcasting approach (Source: Guers & van Wee 2004)

Why can backcasting lead to more sustainable solutions for transportation systems? To begin with, transportation problems, particularly environmental ones are complex and long-reaching – they can take 25 to 50 years to manifest themselves and the impacts are long-lasting. Further, "fixing" transportation problems takes a long time because transportation infrastructure is expensive and turnover (of vehicle fleets, bridges, etc.) is not immediate. The complexity of transportation problems (namely, interactions of different systems and manifestations at different scales) makes it difficult to exact real change through incremental policies. Forecasting is limited to an extension of current practices whereas backcasting provides the freedom to explore the radical changes that are needed for transportation systems. Backcasting, particularly through a participative process, provides an opportunity to take an action-oriented rather than a passive approach and to develop desirable future images and effective policies for moving forward. Backcasting is an important process to inform policymakers in the selection of policy packages and implementation phases and important for the public in a social learning environment. The process and the outcomes of backcasting can help raise public awareness of sustainability issues for transportation and what is truly valued for the future. Further, it can provide a realistic view of what needs to be done in order to achieve a desirable future.

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Chapter 4:

Data Collection & Availability for Sustainability Assessment

Section I: Introduction

Sustainability planning, assessment, and monitoring relies on data from a variety of sources to provide a complete picture of the environmental, economic, and social impacts as well as the basic functionality of transportation projects or agencies themselves. In the United States and internationally, data quality and availability have proven to be significant barriers to comprehensive transportation sustainability assessment (31,58,59). A research team in the UK developed an indicator-led approach to appraising sustainability in transportation. The appraisal method examines relationships among transportation, economy, environment, and society to cover all of the objectives in the UK sustainable development strategy and the European Commission's accepted definition of sustainable transportation. The goal was to operationalize already accepted definitions by selecting appropriate indicators. The research team intended to select indicators that were already in use or that relied on an existing data source in order to help with tracking progress from an established baseline. However, they found that several proposed indicators lacked data sources; in particular, the key social sustainability indicators like out-of-pocket transportation costs, quality and security of local environment for walking and cycling, equity of access to transport network from affordable housing (58).

For certain purposes, like developing performance measures or indicators for project delivery or system conditions, transportation agencies may face a data overload -- there may be too much data to choose from and the agency may struggle with what is the most important or most meaningful data to track. However, when it comes to sustainability assessment (particularly economic and social equity/quality of life impacts) agencies face a lack of sufficient data or may have questions about which measures are meaningful indicators of progress. In responding to survey questions about performance measures, DOTs demonstrated that they collect numerous environmental indicators (some of which are required by law) but fewer economic and social indicators. One DOT in particular expressed difficulty in finding a direct measure for social sustainability. Arizona, Delaware and California DOTs have been working to find appropriate performance measures. They reported difficulty in narrowing the list of measures to a manageable number and selecting the most meaningful ones. Further, data collection is costly and requires significant use of resources, and transportation agencies may find it difficult to prioritize additional data collection over other more urgent needs.

For sustainability, developing indicators may require creative use of available data. For example, several variables can be combined into a quality of life index. When considered alone, the data may indicate a certain state but when considered jointly the data may suggest trade-offs that occur. The UK's and other experiences (29,59,60) suggest that disaggregating traditional transportation statistics by transportation mode, geography or socioeconomic group could be a method for analyzing social equity. Such an analysis would require census data (demographics, geopolitical boundaries) and available transportation statistics.

Organizing indicators into a sustainability framework – like New Zealand, Texas or Missouri – can help narrow down a list of indicators or identify additional data that needs to be collected. Indicators ought to be linked to specific agency goals and the overall agency vision. By linking indicators to specific agency goals, objectives, and

targets, it becomes necessary to sort through all of the available data and only choose indicators that provide a meaningful measure. Rather than collecting and tracking every possible piece of data, only the most important are selected (which can be financially beneficial given limited resources). With a streamlined list of indicators, the transportation agency can then track performance and more easily pinpoint why targets are not met. The agency can also assess trade-offs among different indicators that may result from policies. This must be done with the understanding that performance measures need not be static but must accurately reflect what the agency is trying to accomplish, as what gets measured gets managed. By considering the key indicators for assessing sustainability, gaps in data availability can be identified to guide future data collection or interagency data sharing.

Considerable benefits can be achieved by improving the coordination of existing transportation statistics gathering activities. Data cost effectiveness could be improved significantly. Data quality and usefulness could also be improved by focusing on: comprehensiveness, consistency, frequency, accuracy, transparency, and availability (61). In the meantime, transportation agencies can strive to identify meaningful measures based on available data sources. Following New Zealand and the UK's lead, agencies can also identify measures that they would like to have and potential sources for the data.

Section II: Data Sources

A significant challenge for sustainability analysis, evident in DOT interviews and the literature, is finding the right data at the appropriate geographic scale, level of aggregation, or timeframe. In the United States there are several publicly available and commonly used data sources for transportation and socioeconomic data. Table 4-1 summarizes some of these datasets. Environmental data sources that are used more widely because of NEPA are not included here.

Table 4-1: Publicly Available Datasets for Transportation Analyses

Data Source	Frequency	Geographic Scale	Description
APTA Transit Statistics	Annual	United States; Local providers	Annual statistics for U.S. public transportation; Annual agency-specific statistics; historical time series statistics for US
BTS State Transportation Statistics	Annual*	State	Compilation of transportation statistics from multiple sources (timeframes vary)
DOE's Transportation Energy Data Book	Annual (from 1976)	National	Transportation statistics on fuel consumption, emissions, etc. (http://cta.ornl.gov/data/index.shtml)
EPA's Envirofacts	Periodic, variable	Zip code, city, county, state	Clearinghouse of EPA data sources
FHWA National Bridge Inventory (NBI)	Annual	State (individual bridges)	Condition of bridge infrastructure

Data Source	Frequency	Geographic Scale	Description
FHWA National Household Travel Survey	Variable (1969-2009)	National	Daily travel by all modes and traveler characteristics (http://nhts.ornl.gov/)
FHWA's Highway Statistics	Annual	State and City	Information on US road conditions, highway travel, and expenditures
Highway Performance Monitoring System	Periodic, variable	States	National level highway information system
National Transit Database	Periodic, variable	Nation's Transit Agencies	National database of statistics for the Transit Industry
Texas Transportation Institute	Periodic, variable	Metropolitan Areas (U.S.)	Urban Mobility Report
US Census American Community Survey (ACS)	Annual (from 2005)	Areas with population >65,000	Similar data to US Census long form
US Census Bureau's Annual Economic Surveys	Annual	County and Zip Code	Local economic patterns by industry
US Census Bureau's Decennial Census	10 years	National, state	Demographic data
US Census Bureau's Economic Census	5 years	By industry (or establishment)	Profile of businesses and industry
US Census Bureau's Population Estimates	Annual	Nation, state, counties	Population estimates for year's between decennial censuses by demographic group
US Census Transportation Planning Package	10 years	Local, county, state	Travel data (will be based on ACS)

For purposes of long-range planning, these data sources are produced at an appropriate time interval. However, for sustainability performance monitoring and lower-level planning activities, this data may not be sufficient. For example, there is no single integrated multi-modal database at the federal level. Many MPOs or state DOTs supplement public data sources with regional travel surveys, local land use information (primarily from comprehensive planning or zoning regulations), and data collected in-house (traffic counts, safety statistics, etc.). Additional data may also be available from other relevant state agencies, like economic development and public health departments or environmental agencies.

Data for evaluating system performance is collected regularly by transportation agencies and includes pavement condition, travel times, crash rates, etc. Measuring system performance is a necessary piece of sustainable transportation assessment, but not sufficient on its own. If a transportation system improves its operations at the expense of the environment, economy, and/or society, it may not be sustainable. When taken together, these four areas represent the sustainability of the transportation system and/or agency.

Various DOTs have been collecting data on the environment for several years as a result of the 1969 NEPA and several subsequent laws regulating air quality, water quality, noise, historic preservation, etc. Today agencies are able to evaluate the impacts of projects on the environment, both natural and built, by tracking noise pollution, construction run-off, wetland replacement, material recycling, and other data collected in-house. Agencies

also gather data on operational impacts, both internal (like DOT fleet fuel consumption, energy use, paper recycling) and external (like air quality and highway plantings). Now, with emphasis on climate change and energy independence, transportation agencies are beginning to measure greenhouse gas emissions and fuel consumption. While a considerable amount of environmental data is collected by the transportation agency, additional data is obtained from federal and state resource agencies or local governments.

When it comes to sustainability indicators for the economy or social equity/quality of life, agencies tend to lack sufficient data sources. Aside from estimates of project costs and benefits, a majority of economic data is obtained from outside agencies like the US Census Bureau, state or local economic development agencies, and private data collection companies. Developing social indicators can require creative use of available data. For example, several variables can be combined into a quality of life index; when considered alone the data may indicate one state but when considered jointly the data may suggest trade-offs that occur. The UK experience (29) suggests that disaggregating traditional transportation statistics by geography or socioeconomic group could be an effective method for analyzing social equity. Experience in the United States in applying Health Impact Assessment (HIA) to transportation projects also supports disaggregation of available data as a means for assessing social impacts (60). Such an analysis requires census data (demographics, geopolitical boundaries) and available transportation and health-related statistics. GIS could also aid in such an analysis.

Data sources for GIS are becoming increasingly necessary for early environmental screenings and for assessment of economic, social, and land use impacts. GIS analysis is recommended as an effective way to examine local impacts during a strategic sustainability assessment and is also a valuable visualization and analytical tool for spatial analysis and scenario planning. In interviews with state DOTs, several mentioned using GIS to help identify environmental impacts (Delaware, Tennessee, Florida) and others expressed a desire to do so but cited the availability of data files as a primary barrier. In order to fully utilize GIS analysis, statewide data sources for transportation infrastructure, land use, and environmental features would be necessary. There are numerous GIS data clearinghouses available online, but not all data sources are free, and some may not provide the detail necessary to conduct corridor or project analyses. Additionally, there may be data gaps in states or counties that do not generate their own GIS files. For specific transportation projects, GIS data can be generated by attaching spatial data to existing data sources like transit station locations or employment centers (essentially mapping either manually or with GPS equipment). Creating GIS datasets is often costly and labor-intensive.

The GeoCommunity Data Catalog and Geospatial One Stop (geodata.gov) are two examples of clearinghouses that offer statewide and county-level data. There are also specific GIS data sources with particular relevance to transportation planning. Examples include:

- US Census Bureau's TIGER/Line files include features like roads, railroads, rivers, lakes, and legal and statistical boundaries;
- Bureau of Transportation Statistic's National Transportation Atlas Database (2008) which provides numerous data files that can be downloaded by US DOT region;
- US Geologic Survey data files;
- Environmental data from EPA; and
- US Department of Agriculture Forest Service Geodata Clearinghouse.

Additional GIS resources are provided on the FHWA website.

The data sources presented above are the most commonly used sets for transportation

planning because of the frequency of collection, appropriateness of scale, and convenient format. Additional data sources are available but may not be as useful for transportation planning purposes due to limited scale, less frequent collection, and cost of use (see Table 4-2).

Table 4-2. Additional Transportation and Sustainability Data Sources

Data Source	Frequency	Geographic Scale	Description
United States Data			
Housing and Transportation Affordability Index	Varies	Select US metropolitan regions	Maps housing and transportation costs as percent of income, annual household gasoline expenditures, carbon dioxide emissions from household auto use, and custom comparisons (user selected variables) http://htaindex.cnt.org/
Metropolitan Travel Survey Archives	Varies	State, Metro	Database of travel surveys conducted by US states or metropolitan areas http://www.surveyarchive.org/archive.html
National Highway Traffic Safety Administration	Varies	State, Nation	Safety data and statistics for US states and the nation as a whole http://www.nhtsa-tsis.net/
North American Transport Statistics Online Database	Annual (1996-2005)	Nation	Transportation-related data in twelve thematic categories for the US, Canada, and Mexico http://nats.sct.gob.mx/sys/index.jsp?i=3
TranStats: Intermodal Transportation Database	Varies	Varies	Searchable index of US transportation datasets http://www.transtats.bts.gov/
US Bureau of Labor Statistics' Consumer Expenditure Survey	Annual (1984-2007)	Nation	Statistics on consumer patterns http://www.bls.gov/cex/
International Data (including United States)			
Cross-National Time-Series Data Archive	Annual (since 1815 for some countries)	Nation	Variety of demographic, economic, transportation, education, and other data collected for over 200 countries (must pay for a license) http://www.databanksinternational.com/
EarthTrends Searchable Database	Varies	City, Region, Nation	Database of over 600 variables relating to transportation, environmental systems, energy use http://earthtrends.wri.org/miscell/sitemap.php?theme=0
iRAP International Transport Statistics Database	Varies	International (Nation)	Various statistics for several countries, including the US http://www.iraptranstats.net/
IRF's World Road Statistics	Annual (since 1964)	Nation	Collection of national transport statistics for over 185 countries http://www.irfnet.org/statistics.php
Millennium Cities and Mobility in Cities databases	2001	International (City)	Transportation data on over 100 world cities (pay for service) http://www.uitp.org/publications2/store/index2.cfm?id=5&#mcd

Data Source	Frequency	Geographic Scale	Description
National Footprint Accounts	Varies	International (Nation)	Contains data sources for each ecological footprint including Food and Agriculture Organization of the UN, the International Energy Agency, the UN Statistics Division, and the Intergovernmental Panel on Climate Change http://www.footprintnetwork.org/en/index.php/GFN/page/methodology/
United Nations (UN) Global Urban Observatory Database	Varies	International (City, Nation)	Transportation, land use and other data for world cities http://ww2.unhabitat.org/programmes/guo/

Section III: Applications of Data Sources

This section demonstrates applications of different data sources in various sustainable transportation planning practices and assessment methods identified in the survey and literature. Table 4-3 summarizes various practices, data requirements, sources, and limitations. A similar analysis is provided as part of each case study in Chapter 5. In addition to the publicly available data sources in Tables 4-1 and 4-2, some of the practices require data from private sources, which may not be free or easy to obtain. Also, GIS-based practices depend upon the availability of a comprehensive database, and so may not be easily applied by all state DOTs. Development of GIS databases for the purpose of sustainability assessment requires cooperation among multiple agencies and can be labor-intensive and costly.

Table 4-3. Applications of Data Sources in Transportation Planning and Assessment

Tool	Description	Data Need	Data Types & Sources	Strengths, Limitations, Desired Data
Envision Utah (63)	Regional transportation-land use planning effort in northern Utah	-Land use data -Property values -Environmental data (wetlands, slopes, floodplains, etc.) -Population and employment data -Traffic data	Data gathered and converted into GIS format from: -local comprehensive plans and state land use inventories -tax assessments -state environmental databases and satellite imagery -US Census, regional agencies -Traffic statistics (from DOT) and traffic generation rates (guidebooks) -Public feedback used to shape future scenarios -Land use scenarios input into custom travel demand model	Requires time and resources to prepare data files
Florida DOT's Efficient Transportation Decision-making (ETDM) (64)	Process to anticipate environmental problems early on through public involvement and GIS assessment during planning, programming, and project development	Natural Resources Cultural Resources Community Resources Transportation Project Information Extensive data sets are compiled for each section in accordance with agency agreements and ETDM policies	Florida Geographic Data Library of University of Florida's GeoPlan Center (combines federal, state, local data from resource agencies, MPOs, FDOT, etc.) Incorporate public feedback Build database by transforming existing data into GIS format, using on-line data entry, or field data collection	GIS data may be incomplete or inadequate, requiring manual review of a project alignment; Requires coordination with multiple agencies at least annually to update; adhere to QA/QC measures
Idaho Transportation Department's Greenhouse Gas Emissions Reduction	Calculating and tracking Idaho's transportation-related GHG emissions	GHG emissions from buildings, vehicles and equipment, and employee commuting	EPA emission factors for buildings (electricity and heating), vehicle fleet and equipment, and employee commutes (data based on survey of employees)	Establishing a baseline for future analysis
Minnesota DOT Performance Based Planning & Programming (65)	Uses clear policy priorities, performance trend data, and performance forecasting to guide investment decisions	Various performance measures related to transportation network performance and agency performance	Regularly collected DOT data (including crash statistics, freeway congestion, snow clearance, bridge condition); Transit bus hours (from cities, counties, or regional authorities)	Measures are more linked to transportation system performance and will need to be expanded to evaluate progress toward sustainability

Tool	Description	Data Need	Data Types & Sources	Strengths, Limitations, Desired Data
Missouri DOT Tracker (66)	Quarterly report of measures for 18 outcome areas	-percent of projects without environmental violation -percent of projects protecting sensitive species -Ratio wetlands created/ impacted -percent clean air days -Gallons of fuel consumed by unit -Historic resources avoided/ -protected vs. mitigated -Tons recycled materials used in construction	-DOT data -DOT & USFWS -DOT data, Clean Water Act permits -EPA ozone readings -Statewide financial system -Collected by DOT during planning phase -MoDOT construction management database	Tracker utilizes existing and readily available data sources; additional sustainability focused measures would likely require new data sources
Montana DOT Highway Economic Assessment Tool (HEAT) (67)	Enhanced benefit-cost analysis tool for projects that accounts for system impacts	-Transportation system performance -Sociodemographics (block level data, including population, households, travel patterns) -Employment data at establishment-level and census tract and county level data -Commodity flows -Industrial profiles -Economic data including project cost estimates,value of time for freight movements (by commodity), travel times, economic attractiveness	GIS data repository compiled from public and private sources - U.S. Census, the State of Montana, Highway Performance Monitoring System, Bureau of Transportation Statistics (BTS), private data collection companies such as Reebie, Woods & Poole, Info USA -U.S. Department of Agriculture National Agricultural Statistical Service, Commodity Flow Survey (CFS), IMPLAN, 1997 Economic Census Data on Wholesale Trade, FHWA's Freight Analysis Framework (FAF) -Industry interviews	The tool is data intensive and combines multiple data sources; labor intensive to geocode data into GIS format; private data sources may not be free for use
MultiCriteria Evaluation of Planning Alternatives for Sustainability (62)	Used in comparing metropolitan land use and transportation alternatives based on system performance, environmental, economic and social capital measures and tradeoffs.	20-year land use/ transportation scenarios System Performance Measures: VMT per capita; avg. distance driven per day per person Environmental Indicators: VOC, NOx emissions Economic Indicators: vehicle hours traveled per capita, avg. duration of driving per day per person Social: Equity of exposure to emissions, population exposure to emissions	Atlanta Regional Commission -GIS files & Excel data for land use -Four-step transportation demand modeling inputs and outputs for the Baseline 2005 conditions and Mobility 2030 plan	Evaluates relative rather than absolute sustainability value of different planning alternatives.

Tool	Description	Data Need	Data Types & Sources	Strengths, Limitations, Desired Data
Public Transit Energy & Carbon Footprints (68)	Estimation of the Energy and Carbon Footprints for Public Transit Systems in the 100 Largest U.S. Metropolitan Areas	Transit fuel consumption BTUs and Carbon Emissions	FTA's National Transit Database (data reported by local agencies within metro areas) US EIA published values (for liquid fuels) and estimated state carbon dioxide emissions from electricity generation (State Electricity Profiles)	Only as accurate as data collected by local agencies; aggregation error; missing data from local agencies
Sustainability Footprint (42)	Used in analyzing the impacts of transportation infrastructure systems on regional sustainable development, in particular quality of life contributions	System Sustainability (Quality of Life) – congested travel (% peak vehicle miles traveled or VMT) Waste generation – annual delay per person Resource usage – annual excess fuel consumption	Texas Transportation Institute's Urban Mobility Report, comparing 1990 and 2000 data	Simplified footprint model – more robust measures would require additional data sources (like for safety, accessibility and other social benefits)
Transportation Energy & Carbon Footprints (69)	Method to measure and compare (and potentially track) emissions for metropolitan areas	-Daily VMTs -Fuel consumption for cars and trucks -Energy Use & Carbon Emissions -Urban Form Measures	-HPMS & Highway Statistics (FHWA) -Oak Ridge Laboratory's Transportation Energy Databook, FHWA Highway Statistics, U.S. Census Bureau's 2002 Vehicle Inventory and Use Survey -US Energy Information Administration's (EIA) Published values -2000 Census, 2000 and 2005 County Business Patterns, 2000 and 2005 Zip Business Patterns, 2001 National Land Cover Database, FTA's 2005 National Transit Database	
TxDOT Sustainability Indicators (30)	Recently completed research project to develop sustainability indicators for the strategic plan	Performance Indicators like: -Travel Time Index -Annual severe crashes per mile -Land use balance -Truck throughput efficiency -Capacity addition within Right-of-Way -Daily carbon dioxide emissions	-Calculated with DOT data - Estimation procedure based on Interim Roadway Safety Design Workbook -GIS land use files -% trucks from TxDOT's Road-Highway Inventory and Network -GIS analysis or physical inspection -Estimated by Mobile 6 Emissions Model	Indicators are more focused on transportation system performance rather than sustainability; based on mobility rather than accessibility and do not address social impacts; utilizes indirect measures that are derived from other variables

Tool	Description	Data Need	Data Types & Sources	Strengths, Limitations, Desired Data
WSDOT Sustainability Plan & Progress Report (70)	Annual plan update and progress report on sustainability targets and emerging issues	Agency performance in areas of: -Fleets and transportation -Purchase of goods and services -Paper recycling -Facility construction, operation, and maintenance - Persistent Bioaccumulative Toxins (eg. from herbicides)	Data from multiple DOT departments and other state or federal agencies including: -WSDOT Transportation Equipment Fund (for fuel consumption) - Washington State Ferries Safety Systems Office - WSDOT Systems Analysis and Program Development - WSDOT Purchasing and Inventory Total -WSDOT Regional Offices -Energy Information Administration -WSDOT Environmental Services	Primarily monitors internal agency sustainability
Houston-Galveston Area Council's (H-GAC) Regional Decision Support System (RDSS) (78)	Funded under FHWA's Eco-Logical grant program, RDSS is an interactive, GIS-based mapping tool used to integrate long-range transportation and environmental planning. First consensus-driven, regional-scale tool for identifying priorities for future conservation. Incorporated into H-GAC's 2040 Regional Transportation Plan. RDSS can be used for mapping on Internet Explorer with Adobe Flex viewer or ArcGIS users can stream the data into their own GIS projects.	•Eco-types: ecosystems specific to the H-GAC region, including bottomland and upland forests, tidal wetlands, coastal prairies, and water bodies. •Landcover •Water quality data •2035 road network •Watershed data •Cumulative Metric Rankings •Other local and H-GAC data relevant to environment, transportation system, and growth	All data except ecotypes available in GIS format from H-GAC (landcover and road network), EPA (water quality, species), USGS (watershed) Ecotypes were mapped using GIS – approximately 12,000 units mapped in 4 months Cumulative Metric Ranking incorporates quantitative measures (like threatened and endangered species) and qualitative measures like ecotype quality (from observations using aerial photography and soil and geologic maps). Species indentified using EPA's Geographic Information System Screening Tool (GISST). Metrics and methodology for ecotype quality is described in the project report.	Scale of project was regional (8 counties), so limited mapping units to 100-acre minimum and thus could not map freshwater wetlands individually. Could not conduct on-the-ground verifications. Therefore, data not appropriate for site-specific evaluations. Data is publicly available on Internet, so sensitive information such as threatened and endangered species could not be accessed.

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Chapter 5:

Case Studies

NAVIGATING THE CASE STUDIES

Incorporating sustainability principles into transportation planning is a process that needs to be customized to account for the needs of different states and regions. Sustainable transportation may be defined to emphasize different criteria based on a community's priorities, opportunities, and constraints. Further, there is a wide range of sustainability activities at transportation agencies, which put them on different paths. An agency that already has a sustainability plan is starting from a very different place than one that has just started to talk about sustainability beyond environmental stewardship. Agencies that have already created interdisciplinary teams or hired new staff to deal with sustainability issues are at an advantage to those lacking personnel and experience. Finally, agencies that are operating in states with sustainability legislation (e.g., Oregon) and have different levels of funding available for sustainability initiatives, have an easier time prioritizing those initiatives over other programs. These differences mean that there is no "one-size-fits-all" sustainability program that all transportation agencies can implement.

Nevertheless, a sustainability framework can work for different transportation agencies by letting them determine what sustainability means in their context or what it would entail to make their agency, system, and community more sustainable. Customizing sustainability for different transportation agencies requires agreement on what needs to be sustained and how to best sustain it in a context-sensitive way. It also needs an understanding of what needs to be developed (e.g. what elements offer economic competitiveness, improved social quality of life, etc.) and how best transportation can be used to drive the needed development. Each agency needs to identify their critical priorities (climate change, rural economic development, congestion, etc.), which may be guided by state mandates. They then need to identify gaps in the planning process (vision and goals, performance measures, design guidelines, etc.) where they can introduce sustainability principles. Phased implementation will depend on resource levels, both financial and personnel. Sustainability practices, like those identified in this guidebook, can be classified in different ways and combined into packages that cover all parts of the planning and project development process and all sustainability objectives. Again, the package for each DOT may look different based on their critical issues, available resources, and previous experiences with sustainability.

This chapter presents a menu of options for introducing sustainability principles into transportation planning activities. The table of contents classifies the case studies by critical issue(s) addressed, phase of the planning and project development process affected, and the type of tool or practice described. Taken together, the case studies cover all of the components of transportation sustainability planning (environment, economy, society, system performance) and span the entire planning and project development process. Transportation agencies can consider their sustainability goals and gaps, and take a look at case studies that address their specific needs.

Case Study	Critical Issue(s)	Phase(s) of Planning Process	Type of Practice or Tool	Pages
1 - Caltrans Smart Mobility Framework	Strategic Planning; Performance Measurement	Goals and Objectives, Performance Measures, Evaluation	Sustainability Planning, Performance Measurement, Land Use and Transportation Planning	63-68
2 - PennDOT Smart Transportation	Strategic Planning	Goals and Objectives, Alternative Improvement Strategies	Context-Sensitive Solutions, Transportation & Land Use Coordination, Multi-modal Planning; Inter-Agency Cooperation	69-73
3 - New Zealand Ministry of Transport 2008 Transport Strategy	Strategic Planning; Performance Measurement	Goals and Objectives, Performance Measures, Evaluation	Sustainability Plan; Performance Measurement Framework	75-78
4 - Caltrans Regional Blueprint Planning	Strategic Planning; Climate Change; Performance Measurement	Goals and Objectives, Alternative Improvement Strategies, Performance Measures, Evaluation	Regional Planning; Transportation & Land Use Coordination; Climate Change	79-84
5 - NJDOT New Jersey Future In Transportation (NJFIT)	Strategic Planning	Goals and Objectives, Alternative Improvement Strategies, Performance Measures, Evaluation	Context-Sensitive Solutions, Transportation & Land Use Coordination, Multi-modal Planning	85-95
6 - NYSDOT GreenLITES	Climate Change (Green Design)	Evaluation	Green Transportation Standards	96-100
7 - WSDOT Gray Notebook	Performance Measurement	Evaluation, Performance Measures	Performance Measurement	101-106
8 - ODOT Investment Scenarios	Fiscally-constrained Planning	Alternative Improvement Strategies, Evaluation	Financial Sustainability; Multi-criteria Decision-making; Scenario Planning	107-110
9 - Sustainability Diamond	Strategic Planning	Evaluation	Multi-criteria decision-making (MCDM); Visual decision-making tool	111-114
10 - Health Impact Assessment	Social Sustainability Assessment	Data, Analysis Methods, Evaluation	Social Sustainability	115-123
11 - NYSDOT Climate Change and Energy Efficiency Team	Climate Change	Goals and Objectives, Data, Analysis Methods, Evaluation	Climate Change; Energy Use/Efficiency	124-128

12 - Caltrans Climate Action Program	Climate Change	Goals and Objectives, Alternative Improvement Strategies, Evaluation, Performance	Climate Change	129-133
13 - WSDOT Climate Change Initiatives	Climate Change	Goals and Objectives, Alternative Improvement Strategies, Evaluation, Performance Measurement	Climate Change, GHG Emissions Monitoring	134-140
14 - London Sustainable Freight Distribution Plan	Freight Planning	Goals and Objectives, Alternative Improvement Strategies	Freight Planning	141-146
15 - WSDOT Freight Planning	Freight Planning	Goals and Objectives, Alternative Improvement Strategies	Freight Planning	147-152
16 – Comprehensive Life Cycle Assessment for Sustainability	Strategic Planning; Performance-based Planning	Alternative Improvement Strategies, Evaluation	Financial Sustainability; Multi-criteria Decision Making	153-158

What approaches could help all agencies plan for sustainability?

Despite differences in sustainability priorities among transportation agencies, some solutions are applicable to all transportation agencies. Take urban and rural areas as an example. The best option in a rural area may be to build or expand a roadway to provide access between communities. However, construction can still be done in a more sustainable way that minimizes impacts, resource consumption, waste, maintenance costs, etc. A green rating system, like NYSDOT's GreenLITES, is a tool that works for both urban and rural areas (see Case Study 6). It comes down to planning in a context-sensitive manner. At a more strategic level, there are certain programs and policies that can help all agencies advance planning for sustainable transportation.

Sustainability Targets, Not Standards

The term "standards" implies inflexibility. Rather than being limited by standards, transportation agencies could develop targets, or actionable goals, and then determine how best to achieve them. This strategy is being used in the EU and New Zealand (Case Study 3 describes New Zealand's approach to sustainability targets). In the EU, targets for emissions reductions or mode splits are set for the entire union and then translated down to the member states. The European Union coordinates sustainability at a high level through the Common Transport Policy (CTP) and the Framework Program (FMP). The goal of a "common" transport strategy is to remove barriers to free movement of goods and people throughout the EU by promoting a balanced network and sustainable development patterns. Green papers (discussion papers on a specific subject area) and White papers (proposals for EU community actions on a particular topic) are a primary means of communication between the EC and member states (32). These papers provide policy guidance that supports the CTP, but the member states can develop their own initiatives to meet the targets and policy goals. Program development and implementation is aided by the FMP, which establishes the priorities and funding for the European Union's research, technological development and demonstration activities over a five year period (33). The FMP is carried out by government offices, universities, and private consultants in the Member States.

Sustainability laws and directives

As was observed in the literature review, countries like the United Kingdom and New Zealand, which are viewed as sustainable transportation leaders, have strong national policies that guide planning. Similarly, transportation agencies that are considered leaders (by FHWA, AASHTO, DOTs), have mandates or strong support from state lawmakers for sustainable transportation planning. The policymaking process helps generate critical support for state DOT activities that are not explicitly related to mobility. Further, they help to prioritize new DOT initiatives at a time when financial resources are very limited.

Land use policies are a common way states attempt to make transportation planning more sustainable. Unfortunately, as a result of the authority of local governments to determine land use policies, only a few of these policies actually provide the state transportation agencies with power to influence land use decisions. The most recognizable states with smart growth or land use legislation with ties to transportation are Washington and Oregon, but Maryland, Florida, North Carolina, Pennsylvania, and Massachusetts also have legislation or executive orders related to transportation-land use coordination.

Recently, there has been a wave of state policies related to climate change, some of which are in response to regional efforts to reduce greenhouse gas emissions. The three regional efforts are the Western Climate Initiative, the Regional Greenhouse Gas Initiative (Northeast and Mid-Atlantic states), and the Midwestern Regional Greenhouse Gas Reduction Accord. As of January 2009, 27 states had adopted greenhouse gas reduction targets either by law or by executive order (Reuters 2009). Many of the state policies, like greenhouse gas budgets, do not directly mandate activities for the state DOT but they do require cooperation of multiple agencies to achieve the goals. California was the first state to pass comprehensive legislation for greenhouse gas reduction in 2006, following a 2005 Executive Order that set reduction targets. In order to do its part to reduce emissions, Caltrans works closely with the California Air Resources Board and serves on the Governor's Climate Action Team (see Case Study 12). Colorado's state legislature has taken a more direct approach – legislation passed in March 2009 requires that the statewide transportation plan (prepared by Colorado DOT) address greenhouse gas emissions reduction by finding ways to serve mobility needs without expanding roadways. New York State government has also been proactive in addressing greenhouse gas emissions from transportation and the potential implications of climate change. A new statewide energy plan was released in 2009 and contains energy demand and price forecasts, assessment of energy resources, and strategies for transportation and other sectors. In August 2009, Governor Paterson signed Executive Order No. 24, which set a goal to reduce greenhouse gas emissions in the state by 80 percent below the 1990 levels by the year 2050. To achieve the goal, the Executive Order created a Climate Action Council with a directive to prepare a Climate Action Plan. In response to the state's energy and climate change directives, NYSDOT established a Climate Change & Energy Efficiency team (see Case Study 11).

Those states with Smart Growth legislation, comprehensive planning requirements, climate change mandates, etc. are better able to focus on and plan for the impacts of transportation infrastructure development on other systems.

Intra-agency and Interagency Collaboration

Collaboration was a key message of the first Green Streets and Highways Conference hosted by American Society of Civil Engineers (ASCE) and Transportation & Development Institute (T&DI) in November 2010. Successful sustainability initiatives

require collaboration because most transportation sustainability problems cross jurisdictional boundaries and impact multiple systems (environment, economy, community life, etc.). Working toward sustainability of the transportation system requires first collaboration within a transportation agency among the various departments and work groups. This may require temporary or permanent institutional changes like a sustainability task force, sustainability director or program manager, or an entire sustainability department. At another level, sustainability initiatives require interagency collaboration, which takes two forms: relationships between multiple transportation agencies (different levels of government, different modes, and different states) and relationships between multiple disciplinary agencies (environmental resources, economic development, historic preservation, etc). Such relationships are vital during all phases of the planning process, providing better, more comprehensive data, a consistent message to the public and policymakers, and implementation assistance. The case studies provide great examples of collaborative efforts, including PennDOT and NJDOT for Smart Transportation; transportation, public health, local planning agencies for Health Impact Assessment; NYSDOT with MPOs, NYS Energy Planning Board and other agencies for the Climate Change and Energy Efficiency Team.

Comprehensive Education Campaign

As with any new idea, sustainability needs "champions" to push it forward and a critical mass to support it. A comprehensive education campaign aimed at different stakeholder groups (transportation professionals, the public, policymakers, etc.) is a necessary step. For example, New NYSDOT tackled the transportation-land use connection by holding annual conferences to explain new policies or programs to other state agencies and local governments. In October 2007, the DOT held a land use conference for MPOs and local governments. The DOT also launched a "smart planning" website that presents all of its land use/smart growth policies and programs in one place and advertises training and hands-on assistance. When PennDOT embarked on the Smart Transportation movement, the agency made a major push to educate stakeholders. A unique feature of the movement is considerable outreach both internally (PennDOT employees) and externally (local governments, transportation professionals, civic groups, Pennsylvania residents) to explain Smart Transportation and how stakeholders can work together to accomplish goals. More information about PennDOT's approach can be found in Case Study 2.

Integrity in the planning process

To truly address sustainability problems, there needs to be integrity in the transportation planning process, meaning sustainability must be integrated throughout the entire process. Increasing numbers of transportation agencies are strategically committing to sustainability as a guiding framework for planning and project development. In order to act on this commitment, agencies need appropriate policies, tools, and methods for assessing sustainability at different stages in the planning process. A general planning framework includes visioning, the development of goals and objectives, the

generation of project alternatives, the development of alternative transportation plans, and performance measurement (Figure 5-1) (71). There are many examples of individual practices that can be added to incrementally transform the planning process. Examples include establishing "sustainability indicators" rather than traditional mobility indicators, which transforms the "performance measurement" stage to align with sustainability goals and objectives. Agencies can also add "establish targets" as an explicit stage of the process to move toward more active and dynamic assessment of sustainability. In addition to these practices, there are examples of state DOTs that have developed comprehensive frameworks, like PennDOT and Caltrans. Developing new practices can refine even comprehensive frameworks. For example, social sustainability analysis is still lacking in several sustainability frameworks. Including Health Impact Assessment as a long-range planning tool is one way to address that gap. The case studies' table of contents on the next page lists different phases of the planning process that each case study fits within.

Sustainable funding sources

As pointed out in earlier discussions, limited resources hinder the implementation of new sustainability initiatives. Providing transportation funding sufficient for maintaining the existing transportation infrastructure and putting in place capacity expansions to meet future demands is one of the most challenging public policy issues facing federal, state, and local officials. Given the diversity of funding contexts at all levels of government, the most likely descriptor of future transportation funding programs is that they will be "menus" of different funding and financing strategies. In addition to finding new, sustainable funding sources, transportation agencies can also develop new processes for allocating funds to projects in a way that ensures progress will be made toward more sustainable transportation systems. There are already examples of prioritization and allocation processes that can be based on sustainability goals. Oregon DOT develops investment scenarios as part of its long-range planning process, which explore the impacts that different funding and policy packages would have on the transportation system. The packages are developed around different themes or emphases that could reflect sustainability goals (Case Study 8). Minnesota DOT and Washington State DOT use performance-based planning aided by comprehensive performance measurement and reporting frameworks. Several research efforts are underway to designate sustainability indicators that could be incorporated into those frameworks.

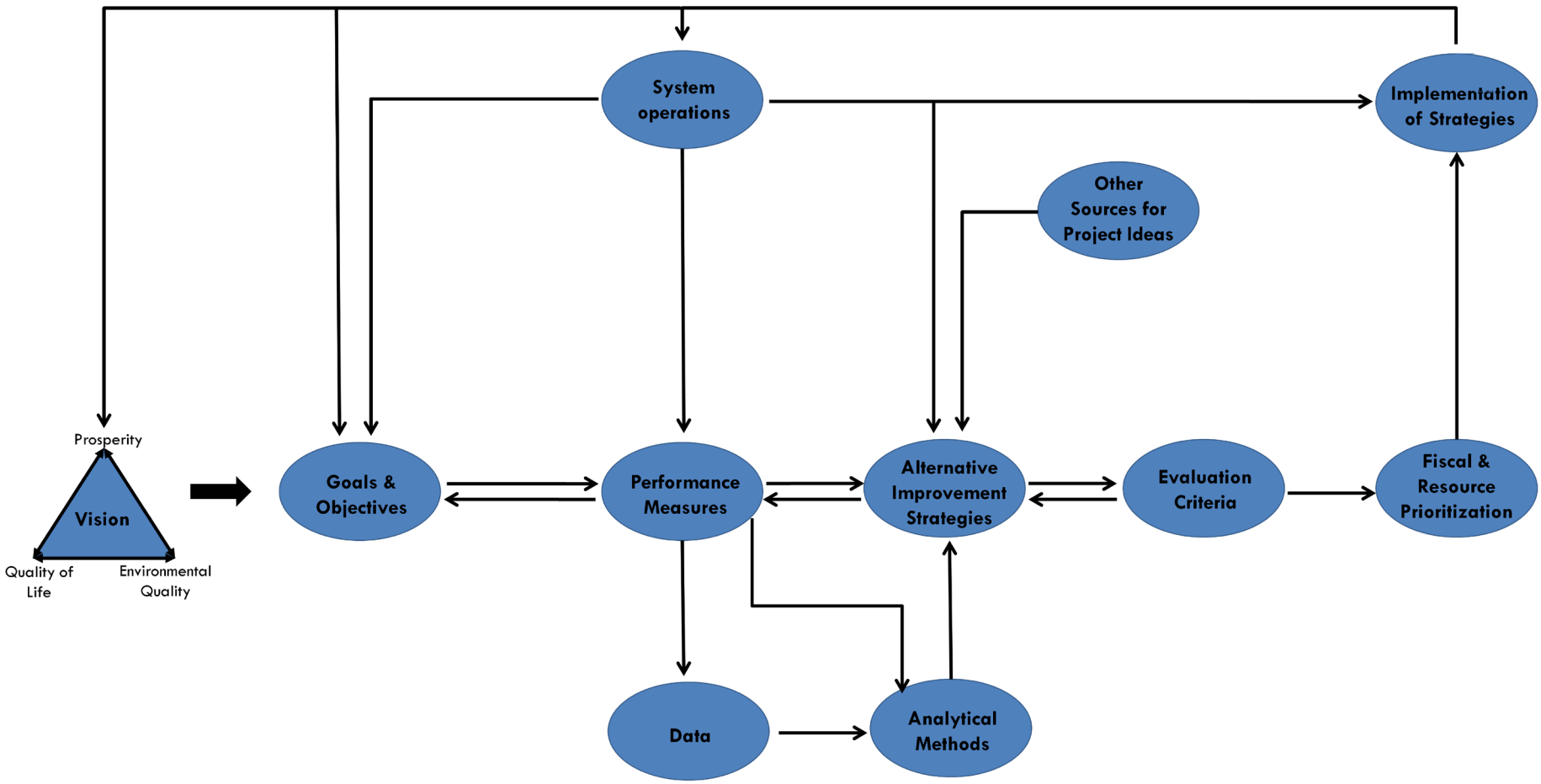

Figure 5-1. Transportation Planning Framework (Source: Meyer & Miller 2001)

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CASE STUDY

CALTRANS
Smart Mobility Framework

Strategic Approaches:

Targets

Collaboration

Integrity in Planning Process

Partner:

US Environmental Protection Agency (EPA)

Brief Description:

Caltrans' vision for the 2025 California Transportation Plan is of the three Es of sustainability -- environment, economy, and equity. Following from this vision, Caltrans worked with the EPA on a pilot project called the Smart Mobility Framework. The project investigated how to build a framework for transportation investments to answer the question "is this sustainable?" SMF provides a tool to assess how well plans, programs and projects meet smart mobility principles and objectives.

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How did Smart Mobility get started?

California statutes, plans, and policies envision a transportation system that accommodates future growth in a way that is equitable, respects the environment, and fosters a sustainable economy. Caltrans felt that practical tools were needed to evaluate whether this vision could be realized. In 2007, the agency was one of six recipients of Smart Growth Implementation Assistance (SGIA) from USEPA. With SGIA, Caltrans received initial technical assistance to develop the framework. The Smart Mobility Framework (SMF) will help Caltrans address State mandates to find solutions to climate change and reduce greenhouse gas emissions, the need to reduce per capita vehicle miles traveled, the demand for a safe transportation system that gets people and goods to their destinations, and the commitment to create a transportation system that advances social equity and environmental justice, as set forth in Caltrans' California Transportation Plan [1, 2].

What is the Smart Mobility Framework?

"Smart Mobility moves people and freight while enhancing California's economic, environmental, and human resources by emphasizing: convenient and safe multi-modal travel, speed suitability, accessibility, management of the circulation network, and efficient use of land."

The SMF for transportation planning and project development is centered on six principles, which are reflective of sustainability:

1. Location Efficiency - Integrate transportation and land use in order to achieve high levels of non-motorized travel and transit use, reduced vehicle trip making, and shorter average trip length while providing a high level of accessibility.
2. Reliable Mobility - Manage, reduce, and avoid congestion by emphasizing multi-modal options and network management through operational improvements and other strategies.
3. Health and Safety - Design, operate, and manage the transportation system to reduce serious injuries and fatalities, promote active living, and lessen exposure to pollution.
4. Environmental Stewardship - Protect and enhance

the State's transportation system and its built and natural environment. Act to reduce the transportation system's emission of GHGs that contribute to global climate change.

5. Social Equity - Provide mobility for people who are economically, socially, or physically disadvantaged in order to support their full participation in society. Design and manage the transportation system in order to equitably distribute its benefits and burdens.

6. Robust Economy - Invest in transportation improvements that support the economic health of the State and local governments, the competitiveness of California's businesses, and the welfare of California residents. [2]

The Smart Mobility principles will be integrated into Caltrans' day-to-day operations. The principles will be introduced into a wide range of DOT and partner activities including:

- Planning and Programming,
- Standards and Guidelines,
- Transportation Projects and Programs,
- Development and Conservation Projects and Programs,
- Decision Support, and
- Performance Measures.

How was the Smart Mobility Framework developed?

Criteria for developing the framework [1]:

- **Density**
- **Design**
- **Configuration Connectivity**
- **Safety**
- **Parking Strategies**
- **Mixtures of land uses**
- **Availability of transit**
- **Complete Streets**
- **Open spaces**

Caltrans' SMF was developed in partnership with the California Governor's Office of Planning & Research (OPR) and the California Department of Housing & Community Development (HCD). It was completed in two phases. The first phase used technical assistance from USEPA to gather and synthesize data from California, other states, regional agencies, and State DOTs across the country. These findings were discussed at a stakeholder workshop (including participants from Caltrans, partner agencies, and other organizations) and used to establish the definition and themes for Smart Mobility in California. The second phase of the project used State Planning & Research funds to develop the specific framework that will guide Caltrans employees in evaluating proposed transportation plans and projects by principles of Smart Mobility. The phase involved another stakeholder workshop to gather feedback on a draft guidebook. Phase II funding also supported publication and distribution of the final guidebook, Smart Mobility 2010: A Call to Action for the New Decade. Future phases of the project will refine the framework so that Caltrans and other agencies can develop effective screening tools to evaluate their plans and projects [2]. Framework development was guided by an interdisciplinary technical advisory team (TAC) that reviewed interim products and feedback from stakeholder workshops. The SMF will ultimately be used to guide development of products and assess plans, programs, and projects at various levels (state, regional, local) across the state (urban, suburban, rural areas) [1].

How will Smart Mobility be implemented?

The SMF guidebook establishes priorities and provides tools for beginning to implement Smart Mobility at Caltrans and at partner agencies. This section will describe three of those "tools": Smart Mobility Place Types, Interregional Blueprints, and the Action Plan & Checklist.

"Place types are tools to guide change so that communities evolve to achieve higher levels of Smart Mobility benefits."

Smart Mobility Place Types

Seven "place types" are specifically designed as tools for planning and programming that implement Smart Mobility. The place types represent generic development patterns that are present throughout California. The place types are: Urban Centers, Close-in Compact Communities, Compact Communities, Suburban areas, Rural and Agricultural Lands, Protected Lands, and Special Use Areas. Table 5-1 is a snapshot of the place types described in Smart Mobility 2010. The report provides guidance for how Smart Mobility can be implemented in each place type, offering resource documents and example guidelines for each in its appendix. The key implementation activities are grouped into Planning, Transportation Projects and Programs, and Development and Conservation Projects and Programs [2].

Table 5-1. Smart Mobility Place Types.

Place Type	Summary Description (existing or planned character)	Presence of Location Efficiency Factors: Community Design	+	Regional Accessibility	Examples
3. Compact Communities	Historic cities and towns as well as newer places characterized by strong presence of community design elements. While most compact communities are outside of metropolitan regions, some are on the periphery of metropolitan regions.	High	+	Weak to Moderate	Eureka, San Luis Obispo, Paso Robles, Santa Barbara
4. Suburban Communities	Communities characterized by a low level of integration of housing with jobs, retail, and services, poorly connected street networks, low levels of transit service, large amounts of surface parking, and inadequate walkability. For the purposes of the Smart Mobility Framework, suburban communities are defined by weak-to-moderate presence of location efficient community design factors. They vary with respect to regional accessibility; some suburban communities are located within easy commute distance of urban centers, while others are not. Places that share characteristics with suburban communities---such as a high proportion of detached housing, are categorized as being in the suburban community place type only if they match the place type characterization relative to location efficiency factors.				
4a. Centers	Mid-size and small downtowns, lifestyle centers, or other activity centers embedded within suburban communities.	Moderate	+	Variable	Moderate to High density examples: typical areas of Orange County and Inland Empire counties. Low to Moderate density examples: Central Valley, Salinas Valley, and Sierra foothill suburbs.
4b. Corridors	Arterial streets with a variety of fronting development types, frequently characterized by inadequate walk and bike environments, low land use efficiency and poor aesthetics.	Weak	+	Variable	
4c. Dedicated Use Areas	Large tracts of land used for commercial purposes such as business or industrial park or warehousing, or for recreational purposes such as golf courses.	Weak	+	Variable	
4d. Neighborhoods	Residential subdivisions and complexes including housing, public facilities and local-serving commercial uses, typically separated by arterial corridors.	Weak to Moderate	+	Variable	

Source: Smart Mobility 2010: A Call to Action for the New Decade

Interregional Blueprint

For several years, Caltrans has administered the Regional Blueprint Planning program, which helps regional governments develop future land use and transportation visions (more information can be found in Case Study 4). As part of the Smart Mobility program, the Department will develop a statewide interregional, multi-modal blueprint to be known as the California Interregional Blueprint (Interregional Blueprint or CIB). The CIB will go beyond the scope of the existing California Transportation Plan (CTP) by analyzing the benefits of multi-modal, interregional projects on the transportation system. In line with the regional program, it will also improve understanding of the role of integrated land use and transportation investments in meeting critical strategic growth and sustainability goals. In addition to weaving together existing Regional Transportation Plans into a statewide blueprint, the CIB will result in stronger partnerships with regional and local agencies and tribal governments, and better data for future decision making at the State, regional, and local levels [2].

Action Plan and Checklist

Also included in the guidebook is an Action Plan that identifies the concepts, methods, and resources essential for implementation of the SMF. The Smart Mobility Action Plan identifies ten implementation themes:

1. Increase the impact and effectiveness of the SMF and the call to action by widely dis seminating information.
2. Support an expanded Interregional Blueprint Planning program.
3. Integrate the SMF consistently into Caltrans policy and practice.
4. Integrate the SMF policy and practice with activities of other agencies and departments, like the Strategic Growth Council and SB375.
5. Collect, develop, and use data and tools needed to implement the SMF including performance measures.
6. Revise planning and programming procedures to reflect the SMF, particularly STIP guidelines.
7. Revise design standards and procedures to reflect the SMF, starting with revision of the Caltrans Highway Design Manual (HDM) and implementation of the Department's complete streets policy.
8. Undertake major cross-functional initiatives, like a comprehensive program to insure strong consideration of location efficiency factors in newly-developing areas, and a funding initiative to identify adequate resources for transit and rail capital investment and operations.
9. Integrate the SMF into local government land use and transportation planning and implementation activities.
10. Encourage local government Smart Mobility implementation assessment and evaluation activities, like advancing the use of multi-modal level of service (LOS).

The Action Plan is presented as a checklist of high priority activities for implementation. The checklist identifies the relevant level(s) for implementation (state, regional, local);

key participants; time frame for initiating the action; reference sections of the handbook; and relevant resource materials [2].

What will Smart Mobility achieve and how will it be measured?

Caltrans' anticipates that several important outcomes will be achievable over a long-term time frame. These outcomes include:

- Improved accessibility,
- Reduced average length and number of trips,
- Social equity,
- Reduced environmental impacts of travel,
- Improved public health,
- Reduced energy costs and vulnerability to price escalation, and
- Economic development.

In order to more easily apply Smart Mobility to project and plan development, Caltrans designated a set of seventeen Smart Mobility performance measures (SMPMs), which are shown in Table 5-2. The measures collectively capture Caltrans' role in context-sensitive solutions, regional blueprints, sustainable com¬munities strategies, corridor system management plans, and Interstate commodity movement. For each performance measure, the Call-to-Action report suggests specific metrics that can be used, identifies tools needed to assess each measure, and suggests sources for the necessary data. The report also provides guidance on how the performance measures can be applied to different place types because not all measures are applicable to all place types. Also, they may require different data collection strategies. Because the SMF is intended to complement and build upon existing policies and plans, the report analyzes the relationship between the proposed SMPMs and Caltrans' Strategic Growth Plan in the California Transportation Plan 2030. To help Caltrans and other agencies use the SMPMs for project assessment or monitoring, the report contains hypothetical examples of SMPM application for (1) Regional Transportation Plan, (2) Context Sensitive Design of an Arterial State Highway, and (3) Corridor Systems

Table 5-2. SMPMs and Smart Mobility principles each is most closely related to.

Principle	Performance Measure*
Location Efficiency	1. Support for Sustainable Growth 2. Transit Mode Share 3. Accessibility and Connectivity
Reliable Mobility	4. Multi-Modal Travel Mobility 5. Multi-Modal Travel Reliability 6. Multi-Modal Service Quality
Health and Safety	7. Multi-Modal Safety 8. Design and Speed Suitability 9. Pedestrian and Bicycle Mode Share
Environmental Stewardship	10. Climate and Energy Conservation 11. Emissions Reduction
Social Equity	12. Equitable Distribution of Impacts 13. Equitable Distribution of Access and Mobility
Robust Economy	14. Congestion Effects on Productivity 15. Efficient Use of System Resources 16. Network Performance Optimization 17. Return on Investment

Source: Smart Mobility 2010

Management Plan. [2]

Resources

[1] Smart Mobility Framework website, http://www.dot.ca.gov/hq/tpp/offices/ocp/smf.html

[2] Smart Mobility 2010: A Call to Action for the New Decade, http://www.dot.ca.gov/hq/tpp/offices/ocp/smf_files/SmMblty_v6-3.22.10_150DPI.pdf

Data Need:

Multiple indicators to measure six principles: location efficiency, reliable mobility, health and safety, environmental stewardship, social equity, and robust economy

Data Sources:

Internal data sources:

- **multimodal focus: auto-median speed, transit-average wait time, pedestrian-density, and cyclists-lane width**
- **safety focus: speed suitability**

External data sources (regional agencies, other state DOTs, stakeholder workshops) used to develop framework with technical help from USEPA to synthesize data

Comments:

Data intensive for some principles; quality-of-life principles (social equality, health and safety, and robust economy) have fewer robust measures

CASE STUDY

PennDOT

Smart Transportation Planning Framework and Design Guidance

Strategic Approaches:

Education

Collaboration

Integrity in Planning Process

Partner:

Pennsylvania DOT with New Jersey DOT and Delaware Valley Regional Planning Commission

Brief Description:

Comprehensive framework for guiding planning and design decisions and partnering with other agencies, states, and local communities to make financially, environmentally, and socially sustainable decisions. development while limiting tax expenditures and satisfying needs of all stakeholders.

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What is Smart Transportation?

In 1999, Pennsylvania recognized that the state's historic pattern of land development and transportation investments was no longer sustainable for a variety of financial, environmental, and social reasons. Further, public funding for all transportation improvements was very limited and costs for new infrastructure were soaring. In response to these challenges, PennDOT embarked on the Smart Transportation movement to use transportation funds efficiently and achieve design flexibility, choices, safety, and land use coordination. The cornerstone of Smart Transportation is partnering with other agencies, states, and local communities to make financially, environmentally, and socially sustainable decisions. In March 2008, Pennsylvania DOT and New Jersey DOT released their collective report entitled "Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities". Since the release of the guidebook, PennDOT has engaged in an extensive internal and public campaign to make Smart Transportation the standard operating procedure for transportation planning and design in the state.

How was the Smart Transportation framework developed?

Smart Transportation is a planning framework that links land use and transportation planning, focuses on system maintenance and preservation, balances priorities among all transportation modes, requires collaboration with planning partners, and emphasizes true fiscal responsibility [1]. Smart Transportation was born out of PennDOT's Sound Land Use Implementation Plan, which was first released in 2000 and updated annually until 2008. The purpose of the plan was to identify the various initiatives PennDOT was taking to improve the linkage between transportation and land use and monitor progress on implementation. PennDOT's transportation-land use activities influenced development of the 2007 Pennsylvania Mobility Plan (the state's long-range statewide transportation plan), which formally introduced the Smart Transportation approach to planning and design. Following release of the Mobility Plan, PennDOT held external partner workshops with other state agencies and local governments and internal staff workshops to share the message. The official definition of Smart Transportation is "partnering to build great communities for future generations of Pennsylvanians by linking transportation investments and land use planning and decision-making" [2]. Smart Transportation is still about addressing the transportation system's ability to meet regional and local mobility needs (for

example, reduce congestion), and balance those needs with other project and community objectives. However, in order to address congestion, project teams are encouraged to use creative approaches (like access management, signal coordination, alternative transportation modes) rather than focusing on intersection or mainline widening. Smart Transportation is supported by ten themes:

1. Money counts
2. Leverage and preserve existing investments
3. Choose projects with high value/price ratio
4. Safety always and maybe safety only
5. Look beyond level-of-service
6. Accommodate all modes of travel
7. Enhance local network
8. Build towns not sprawl
9. Understand the context; plan and design within the context
10. Develop local governments as strong land use partners

It is not a completely new concept but rather an effort to ensure that the ten principles are consistently and consciously applied to all projects and that Smart Transportation becomes the standard approach for PennDOT's day-to-day operations. A unique feature of the movement is considerable outreach both internally (PennDOT employees) and externally (local governments, transportation professionals, civic groups, Pennsylvania residents) to explain Smart Transportation and how stakeholders can work together to accomplish goals. The official motto is "Smart Transportation – it starts with me", and the official website provides resources for how different groups can be involved day-to-day. For example, PennDOT offers training sessions, information sessions, group or agency presentations, and customizable PowerPoint presentations for transportation professionals. Local governments are encouraged to seek out Smart Transportation guidance - PennDOT support and guidance are available to local municipalities when development projects go through the Highway Occupancy Permit (HOP) Process, municipalities prepare transportation elements for comprehensive plans, and local streets are modified, added, or closed. To aide with outreach and partnering, each of the twelve DOT Districts has an Assistant District Executive (ADE) for Design who serves as point person for Smart Transportation.

How is PennDOT accomplishing Smart Transportation?

PennDOT is integrating Smart Transportation concepts into all of their activities through programs and processes like:

- Smart Transportation Guidebook,
- Linking Planning and NEPA (New Project Development Process),
- Right-Sizing or Fitting the Solutions to the Problem,
- Revisions to the Design Manuals,
- Revisions to the HOP Process (Access Management Policy), and
- Smart Transportation Performance Measures in the Long-Range Plan.

A significant milestone was the release of the Smart Transportation Guidebook in March 2008, which was a collaborative effort with NJ DOT and the Delaware Valley Regional Planning Commission. The partnership came out of necessity for coordinating transportation and land use because the Delaware Valley (metropolitan area centered on Philadelphia) consists of five Pennsylvania counties and four New Jersey counties. The guidebook received a 2008 FHWA & FTA Transportation Planning Excellence Award. The guidebook capitalizes on the flexibility of AASHTO Green Book standards and includes matrices that match land use contexts to appropriate design standards and roadway treatments (see Table 5-3 for an example). An important feature of the guidebook is a move from "design speed" to "desired operating speed", which is essentially the speed that highway engineers and community planners would like vehicles to travel at. The desired operating speed is a function of roadway purpose and the surrounding land use context, and it is "enforced" through appropriate design elements like sight distance, horizontal and vertical curves, and streetscaping. The guidebook, which is consistent with AASHTO design standards, is considered a "starting point" for designing all types of transportation facilities in the states of Pennsylvania and New Jersey and emphasizes achieving consensus with local stakeholders and using design exceptions when warranted. Features of the design guidebook (like the matrix shown in Table 3) were incorporated into a new edition of PennDOT's Design Manual Part 2 that was released in August 2009.

Table 5-3. Example "Matrix of Design Values" from Smart Transportation Guidebook

	Community Arterial	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	11′ to 12′	10′ to 12′ (14′ outside lane if no shoulder or bike lane)	11′ to 12′ (14′ to 15′ outside lane if no shoulder or bike lane)	10′ to 12′ (14′ outside lane if no shoulder or bike lane)	10′ to 12′ (14′ outside lane if no shoulder or bike lane)	10′ to 12′ (14′ outside lane if no shoulder or bike lane)	10′ to 12′ (14′ outside lane if no shoulder or bike lane)
	Paved Shoulder Width[2]	8′ to 10′	4′ to 8′ if no parking	8′ to 10′	4′ to 6′ (if no parking or bike lane)	4′ to 6′ (if no parking or bike lane)	4′ to 6′ (if no parking or bike lane)	4′ to 6′ (if no parking or bike lane)
	Parking Lane[3]	NA	7′ to 8′ parallel	NA	8′ parallel; see 7.2 for angled	7′ to 8′ parallel; see 7.2 for angled	7′ to 8′ parallel; see 7.2 for angled	7′ to 8′ parallel; see 7.2 for angled
	Bike Lane	NA	5′ to 6′ (if no shoulder)	5′ to 6′ (if no shoulder)	5′ to 6′	5′ to 6′	5′ to 6′	5′ to 6′
	Median	4′ to 6′	12′ to 18′ for LT; 6′ to 8′ for pedestrians	12′ to 18′ for LT; 6′ to 8′ for pedestrians	12′ to 18′ for LT; 6′ to 8′ for pedestrians	12′ to 18′ for LT; 6′ to 8′ for pedestrians	12′ to 18′ for LT; 6′ to 8′ for pedestrians	12′ to 18′ for LT; 6′ to 8′ for pedestrians
	Curb Return	25′ to 50′	25′ to 35′	25′ to 50′	20′ to 40′	15′ to 30′	15′ to 35′	15′ to 40′
	Travel Lanes	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Roadside	Clear Sidewalk Width	NA	5′	5′ to 6′	6′	6′ to 8′	6′ to 10′	8′ to 14′
	Buffer[4]	NA	6′+	5′ to 10′	4′ to 6′	4′ to 6′	4′ to 6′	4′ to 6′
	Shy Distance	NA	NA	NA	0′ to 2′	0′ to 2′	2′	2′
	Total Sidewalk Width	NA	5′	5′ to 6′	10′ to 14′	10′ to 16′	12′ to 18′	14′ to 22′
Speed	Desired Operating Speed	35-55	30-35	35-50	30	25-30	25-30	25-30

Outcomes of Smart Transportation

As of March 2010, PennDOT was transforming its long range planning process and project development procedures through the Linking Planning with NEPA initiative. The new long-range planning guidance will include project selection criteria that incorporate Smart Transportation themes, and will be used for the program update beginning in July 2011. At the project planning level, Smart Transportation principles will be incorporated into every stage, beginning with the definition of the project problem and continuing

through development of project alternatives, environmental approvals, final design, and advancement of future funding phases.

Smart Transportation has resulted in concrete and permanent change in PennDOT's planning and design activities. In 2009, PennDOT's Design Manuals and project development process were being updated to incorporate the Smart Transportation themes and principles. PennDOT also set aside a small amount of funding to support Smart Transportation projects through the Pennsylvania Community Transportation Initiative (PCTI). In 2009 they received 403 requests for $600 million in projects and selected 50 grants totaling $59.3 million. The breakdown of project types represents the creativity and multi-modal approach of Smart Transportation:16% to bicycle/pedestrian, 17% to roads/intersections/local network, 24% to intermodal/transit-oriented development, 13% to land use & transportation planning/redevelopment, 31% to streetscaping/traffic calming, about 1% (or $285,000) for regional planning. PCTI was intended to showcase how the Smart Transportation process can work and demonstrate best practices for projects. The Smart Transportation website provides numerous case studies of right-sizing and context sensitive design projects that have been constructed throughout the state through PCTI and Smart Transportation outreach. Preliminary observations suggest that the DOT is engaged in more planning studies than before, meaning that rather than initiating a capacity-building project, DOT staff or local governments are first examining the problems on a congested corridor and looking for possible operational solutions or minor physical corrections.

Smart Transportation has created an open and collaborative environment, encouraging local governments to become involved in the process. Less than two years after initiating the campaign, a township approached PennDOT to share their best practices and receive feedback on ways to improve their planning process. The township, county government, and PennDOT district office are engaged in on-going dialog on how to best link land use to transportation decisions.

Outcomes of Smart Transportation will be monitored in the future by performance measures in the scorecard. One measure will track the use of land use studies as a component of planning a capacity-building project. A second measure will reflect the "money counts" (or financial sustainability) theme by monitoring how well preliminary cost estimates are maintained through final design and construction. The Smart Transportation website is frequently updated with new presentations, planning and design guidelines, and news to keep PennDOT employees, local governments, and other stakeholders informed of continual progress and new developments.

Resources

[1] http://planthekeystone.typepad.com/plan-the-keystone-blog/2009/07/plan-the-keystone-and-smart-transportation.html

[2] Pennsylvania Department of Transportation. (2010). Smart

Data Need:

The framework depends on ten goals: money counts, leverage and preserve existing investments, choose projects with high value/price ratio, safety always, look beyond level-of-service, accommodate all modes of travel, enhance local network, build towns not sprawl, understand the context, and develop local governments as strong land use partners

Data Sources:

Internal measures of success:

- **Traffic: peak hours LOS (queue lengths, seconds of delay)**
- **Safety: reduction in number of driveways (field count)**

Internal and external outreach of ideas:

- **Internal: PennDOT employees**
- **External: local government, transportation professionals, civic groups, PA residents**

Comments: **Very comprehensive plan developed using multiple agencies with extensive outreach programs to promote wide use; "performance measures" not identified**

Transportation. http://www.smart-transportation.com/

[3] October 2009: Using Transportation Dollars to Build Sustainable and Livable Communities, Presentation to Pennsylvania Planning Association, www.smart-transportation.com/assets/download/PPA_Conference_100109.ppt

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CASE STUDY

New Zealand Ministry of Transport

2008 Transport Strategy

What is New Zealand's sustainability plan?

Strategic Approaches:

Targets

Laws & Directives

Collaboration

Brief Description:

National transportation strategy and monitoring system based on sustainability principles.

Sustainability Plans and Policies are important because they provide a comprehensive and coordinated way to address sustainable transportation within the transportation agency and across other state agencies. New Zealand Ministry of Transport (the Ministry) released its first plan for sustainable transportation in 2008: the New Zealand Transport Strategy (NZTS). The plan is an update of the 2002 Transport Strategy. In the plan, the Ministry outlines a vision for a sustainable transportation system, to be operationalized by objectives and measurable targets. The objectives are further refined by several indicators to track progress toward achieving the objectives and ultimately the transportation vision. The Ministry also includes a mechanism to periodically review and revise its framework as progress is made or new data becomes available for indicators. While the NZTS is non-statutory, it is supported by a statutory document called the Government Policy Statement (GPS) on Land Transport Funding. Further, NZTS is accompanied by a performance measurement and reporting framework with a procedure to monitor progress towards the objectives and targets in the Transport Strategy and Government Policy Statement. It provides a tool for evaluating the effectiveness of the current policy and for guiding future decisions. The plan also provides accountability by making the monitoring framework publicly available on the web and by publishing an annual report on trends and progress [1].

Ministry of Environment's Definition of Sustainable Transport

Sustainable transport is about finding ways to move people, goods and information in ways that reduce its impact on the environment, economy and society. Some options include: (1) using transport modes that use energy more efficiently, such as walking or cycling, and public transport; (2) improving transport choice by increasing the quality of public transport, cycling and walking facilities, services and environments; (3) improving the efficiency of our car use, such as using more fuel efficient vehicles, driving more efficiently, avoiding cold starts, and car pooling; (4) using cleaner fuels and technologies; (5) using telecommunications to reduce or replace physical travel, such as tele-working or tele-shopping; (6) planning the layout of cities to bring people and their needs closer together, and to make cities more vibrant and walkable; and (7) developing policies that allow and promote these options, such as the New Zealand Transport Strategy.

www.mfe.govt.nz/issues/transport/sustainable/

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Defining a Vision, Objectives, and Targets

The NTZS was established based on sustainability principles. It establishes a transportation vision for 2040: 'People and freight in New Zealand have access to an affordable, integrated, safe, responsive and sustainable transport system." The vision was developed to be consistent with national transport priorities and is supported by five objectives, which advance a "sustainable" system:

- ensuring environmental sustainability
- assisting economic development
- assisting safety and personal security
- improving access and mobility
- protecting and promoting public health

Each objective is broken down into specific performance targets. A total of 15 targets were included in the 2008 strategy with plans to add more by 2010 as data sources are identified to create meaningful measures for them. In order to determine progress, the strategy includes one or more indicators for each target. Table 5-4 indicates how the goals/objectives, targets, and indicators are related.

Table 5-4. Example of related goals, target, and indicator

Goals/Objectives	Ensuring environmental sustainability and assisting economic development
Target	Reduce the kilometers travelled by single-occupancy vehicles, in major urban areas on weekdays, by ten percent per capita by 2015 compared to 2007
Indicator	Distance per capita travelled in single occupancy vehicles in major urban areas on weekdays

The NZTS outlines "strategic priorities" to achieve the plan's objectives. Examples include integrated planning, maximizing the efficiency of the existing network, investment in critical infrastructure, increase in availability of public transport and active modes, new pricing mechanisms to provide transport funding, new technologies and fuels, maintaining and improving international links. NZTS establishes action items for each of these priorities, some of which incorporate strategies from other government plans like the NZ Energy Efficiency and Conservation Strategy. Figure 1 illustrates the framework for the 2008 NZTS, illustrating the alignment of vision and objectives with targets, key challenges and actions.

Implementing and Monitoring the Strategy

NZTS 2008 is set apart in its targets setting because the targets will be statutorily enforced through the Government Policy Statement (GPS) on Land Transport Funding. The

GPS establishes short-term system goals that will be achieved by prioritizing funding over the next six to 10 years. The national strategy and GPS will be used to link national targets with local priorities through the Regional Land Transport Strategies. In addition to the statutory funding statement, NZTS will also be "enforced" through the Transport Monitoring Indicator Framework, which establishes a monitoring and review process that covers: accountability for delivery of the strategy, a monitoring framework, how gaps in knowledge will be dealt with, proposals for strengthening targets, and a review cycle for the strategy. Further, the indicators are being made available to the public via an online interactive version to allow for easy and transparent tracking. The original framework debuted in 2008 as an outcome-based framework, meaning the indicator sets corresponded to specific objectives. A new version of the framework was released in August 2009 and took a theme-based approach so that the framework will remain relevant even as transportation priorities change. The framework includes ten indicator sets covering traditional transportation themes like Transport Volume, Safety and Security, and Access to the Transport System along with transport-related themes like Public Health, Environmental, and GDP and Population. Transportation trends, as revealed by the indicators, will be summarized in an annual report called the New Zealand Transport Statistics document. The first edition of this report was released in July 2009 [3].

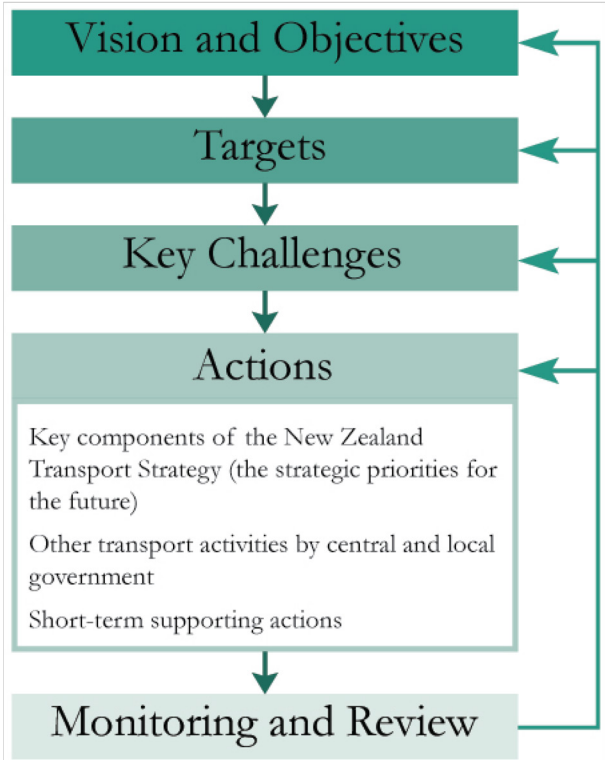

Figure 5-2. Framework for NZTS

Incorporating Stakeholder Feedback

The 2008 Transport Strategy was developed using an open and inclusive process. The Ministry used multiple forums to obtain feedback from stakeholders. In December 2007, the Ministry published a discussion paper on Sustainable Transport, which was released to the public for feedback. The paper discussed the issues facing the transport sector and objectives for moving forward. It also proposed various targets for measuring progress and discussed options for achieving the targets. Stakeholders from the public sector, private sector, and general population were asked for their views on both the strategies and targets. The Ministry utilized national monitoring and trend data, input from other central government agencies, research from New Zealand and overseas, modeling, professional knowledge and judgment, and the stakeholder feedback in preparing the 2008 NZTS [2].

Future Directions

There are plans to revisit the transport strategy - in 2010 to assess its effectiveness. NZ Transport plans to strengthen the targets during that review. After the initial review, the strategy will be reviewed every six years after 2010 to monitor performance and revise strategies to account for uncertainty in some of the external drivers like population growth and transport fuel prices. Over time, the Ministry of Transport hopes that all national transportation targets adopted by other agencies will be consistent with the NZTS. With transportation priorities aligned, multiple state agencies will be able to collaborate for a sustainable transportation system.

Resources

[1] New Zealand Ministry of Transport. (2009a). The New Zealand Transport Strategy 2008, <http://www.transport.govt.nz/home/>, (28 March 2010).

[2] New Zealand Ministry of Transport. (2009b). Questions and Answers on the New Zealand Transport Strategy. <http://www.transport.govt.nz/ourwork/Pages/QuestionsandAnswers.aspx>, (28 March 2010).

[3] New Zealand Ministry of Transport. (2010). Transport Monitoring Indicator Framework. <http://www.transport.govt.nz/ourwork/tmif/>, (28 March 2010).

Data Need:

Various indicators for:

- **Environmental sustainability**
- **Economic development**
- **Safety and personal security**
- **Access and mobility**
- **Public health**

Data Sources:

Statistics NZ; NZ Transport Agency Travel Surveys; NZ Transport Agency Motor Vehicle Register; Ministry of Economic Development; Local and regional transport authorities; Ministry of Transport's Vehicle Fleet Emissions Model

Comments:

Data not available at consistent scale; Data for some desired indicators (particularly public health) not yet collected

CASE STUDY

Caltrans
Regional Blueprint Planning Process

Strategic Approach(es):

Targets

Laws & Directives

Collaboration

Brief Description:

Grant program for collaborative regional visioning and scenario planning that integrates transportation, land use, housing needs, resource protection, and other issues. Communities shape their Blueprints process through selection of performance goals. The Blueprints process will also contribute to Caltrans Climate Action Program (see Case Study on pages 129-133) through greenhouse gas reduction strategies.

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What is Regional Blueprints Planning?

The California Regional Blueprint Planning Program was originally established in 2005 by the California Legislature as a two-year program. It is administered by the California Department of Transportation (Caltrans) Office of Regional and Interag ency Planning. The program was created and has been updated in response to several state and federal directives for regional planning. As a note, regional transportation and land use planning that resulted in "blueprints" began in California in the late 1990s, but a formal grant program was not launched until 2005. The intent of the Blueprints process is to conduct comprehensive scenario planning and have regional leaders, local governments, and stakeholders agree on a preferred land use and transportation scenario that will guide the region's growth for the next few decades. The process is built around interactive public participation that explores trade-offs among transportation planning, land use planning, housing needs, resource protection and other crucial issues like greenhouse gas reduction.

Regional planning legislation

State:

- **AB 69 (Chapter 1253, Statutes of 1972)**
- **SB 45 (Chapter 622, Statutes of 1997)**
- **AB 32 (California Global Warming**
- **Solutions Act of 2006)**
- **SB 375 (Chapter 728, Statutes of 2008)**

Federal:

- **TEA-21**
- **SAFETEA-LU**

How does Regional Blueprints work?

Caltrans has been engaging in collaborative planning through the Regional Blueprint Planning Program since 2005. Regional Blueprints is a voluntary grant program that provides funds for regions to conduct community visioning and model and assess alternate land use scenarios. The program attempts to show local governments the importance of thinking regionally and coordinating planning for transportation, land use, housing needs, resource protection, and other issues (see Framework in Figure 2). Reflecting the diverse goals of Blueprints, the program is supported by three primary partners in addition to Caltrans: the Governor's Office of Planning and Research, the Department of Housing and Community Development, and the Business, Transportation and

Figure 5-3. Regional Blueprints Framework. (Source: Regional Progress Report 2007)

Housing Agency. The Blueprint process has 12 performance goals, and communities are able to shape their own process through the designation of key objectives (or a plan of action) to achieve each goal, and quantifiable performance measures to show progress toward each goal. In the grant process, applicants must also designate who the lead agency will be for each objective, any partner agencies, and the anticipated completion date for each objective. The performance goals are:

- improving multimodal mobility,
- reducing dependency on auto trips,
- working with stakeholders to adopt land use plans and regulations to ensure an adequate supply of housing,
- increasing transportation choices, avoiding and minimizing impacts to natural resources,
- increasing conservation and efficient use of resources,
- improving transportation infrastructure to promote economic competitiveness and quality of life,
- reducing costs and time needed to deliver transportation and other infrastructure projects,

- engaging in scenario planning, reducing the region's greenhouse gas emissions,
- reducing greenhouse gas emissions and planning for climate change impacts,
- using visualization and enhanced public engagement activities, and
- building awareness of and support for critical infrastructure.

The designation of performance measures for each goal is particularly important because they are used to assess and compare the different land use scenarios that are generated during the community outreach process. The inset at right provides examples of performance measures in the Blueprint Program. Blueprints offers a way for regions to respond to state legislation that requires MPOs to achieve greenhouse gas emissions reduction goals through transportation and land use planning. From an environmental sustainability standpoint, a Blueprints process also commonly uses avoidance planning (depending on data availability) in which the agencies use GIS and data support to identify environmentally sensitive lands and plan projects around them.

Regional Blueprints Performance Measures

- **Greenhouse gas emissions levels**
- **Vehicle miles traveled per household**
- **Passengers per transit vehicle mile**
- **Percentage increase in residential density and infill development**
- **Percentage reduction in acres of agricultural or green fields developed**
- **Travel time within key regional corridors**
- **Total person hours of delay**
- **Percent of workers within "x" (15, 30, 45, 60) minutes of their jobs**
- **Percent of jobs (or people) within a quarter/half mile of a transit station or corridor**
- **Variability in travel time on state highways**
- **Percent utilization of highways during peak period**
- **Days exceeding national/state air quality standards by air basin and statewide**
- **Ratio of jobs to housing units over the region's baseline**
- **Proportion of new housing development occur ring within infill areas of the region**

Relationship to Climate Change

Regional land use and transportation planning in California will be significantly affected by the recent passage of SB 375. This Bill is arguably one of the most far-reaching pieces of legislation in the US, aiming to tie greenhouse gas emission reductions to transportation investment decisions. Passed in late 2008, SB 375 requires the state Air Resources Board (ARB) to develop by 2010 regional greenhouse gas emission reduction targets to be achieved from the automobile and light truck sectors for 2020 and 2035 through changes in development patterns. Targets will be revised every eight years to conform to a unified housing and transportation planning schedule set up by the Bill. MPOs must prepare a "sustainable communities strategy" (or SCS) to reduce the amount of vehicle miles traveled (VMT) in their region and show that the ARB's targets can be attained. The regional SCS, even if it conflicts with local plans, will become part of the official regional transportation plan for the region, thus integrating the new state policy into the federally-required transportation plan. Further, SB 375 requires that regional transportation funding decisions be consistent with the region's SCS. Given the new planning requirements, SB 375 will likely increase demand for Regional Blueprint grants and planning assistance. In addition to MPO planning requirements, developers would get relief from some of the state's environmental regulations if projects are consistent with the adopted sustainable communities strategy (e.g., transit-oriented developments), and cities

are required to update their housing plans to be consistent with this policy. It is important to note that the emission reduction targets are on a per capita basis, meaning reduction in per capita emissions may mask a continued rise in total emissions if strategies do not address both.

It is likely that the impact of SB 375 will not be seen for years. Because the community strategy's tie to land use is incentive-based, and given that local governments are not required to comply with the regional plan, it is not clear what ultimate impact SB 375 will have on land use decisions. From the viewpoint of sustainability, however, tying together housing and transportation planning is an important step forward. With respect to funding, the law states that funding decisions must be consistent with the SCS, which is a laudable goal, but whose actual impact will have to await local decision maker definition of "consistency." The exemption and streamlining of state environmental review for development projects that are determined to be consistent with the SCS could foster a shifting in development investment in urban areas in California. This is perhaps of greatest interest to developers and the point likely to have the greatest short term impact. Specifically, SCSs are likely to concentrate future development around transit stops. From a sustainability perspective, this could have tremendous influence on urban development patterns over the long term.

Examples of Blueprints Planning Activities

From 2005 to 2009, eighteen Metropolitan Planning Organizations (MPOs) and fifteen rural Regional Transportation Planning Agencies (RTPAs) participated in the grant program. The agencies have received a total of twenty million dollars in federal regional transportation planning funds from Caltrans. In 2009 alone, five million dollars were distributed to nine Metropolitan Planning Organizations (MPOs) and nine rural Regional Transportation Planning Agencies (RTPAs) across California to support local and regional transportation planning activities.

An example of a completed grant is the Sacramento Region Blueprint Transportation and Land Use Plan, which used innovative technology to develop and build consensus around its preferred growth scenario. The tools used by Sacramento in its scenario development include:

- Visioning with the I-PLACE3S software – The software allows participants of design workshops to explore multiple land use scenarios and immediately see how planning and design decisions made today will influence development patterns, modal choices, redevelopment potential, and livability 50 years from now.
- Infrastructure Cost Model - iMPACS was developed to estimate costs of needed infrastructure based on development scenarios modeled in I-PLACE3S. The model covers infrastructure costs associated with culinary and secondary water, waste water treatment, dry utilities, roads, and parks.
- Travel Model – The transportation impacts of the regional growth scenario can be precisely modeled using one of region's two travel demand models: a traditional four-step travel demand model called the Sacramento Regional Travel Demand Model (SACMET), or the Sacramento Regional Activity-Based Simulation Model (SACSIM), which is still being refined.

In December 2004, the Sacramento Area Council of Governments adopted the preferred regional blueprint scenario and in 2008 it was incorporated into the Metropolitan Transportation Plan for 2035. The preferred scenario serves as the land use basis on which transportation investment decisions are made [3].

What impact has Blueprints had on regional transportation planning?

The Regional Blueprints Planning Program has had concrete impacts on planning in California. For example, to fulfill a Blueprints goal, a sales tax measure in San Diego had an environmental enhancement category with funds directed towards protecting habitat areas. Impacts can also be seen at the metropolitan level: Sacramento studied a more compact land use scenario as one of its alternatives, and as a result a compact development pattern is being adopted in local general plans and incorporated into rural planning to guide land preservation throughout the metropolitan region. The outcomes of the first few years of the Regional Blueprints Planning program were formally assessed in the California Regional Progress Report 2007. The report measured progress by comparing performance of Blueprints regions in 2007 to their historic performance (usually year 2000 depending on data availability) in 18 areas. The report concluded that the fourteen regions tell mixed stories, with some showing progress and others not, or at least progress had not occurred in the same areas. Eleven of the fourteen regions reportedly made progress on at least five place measures, which are the measures most closely linked to the goals of Blueprints.

"Caltrans Regional Blueprints program wins Federal Highway Administration's Environmental Excellence Award.

The Regional Blueprint planning program received an Environmental Excellence Award from FHWA in the category of Air Quality Improvement and Global Climate Change. The award was presented at the ICOET conference in September 2009 in Duluth, Minnesota and was one of four awarded to Caltrans."

Caltrans and the Strategic Growth Council (SGC) sponsored a second Regional Progress Report, which was released in December 2010 and involved collaboration of over 40 state, regional, non-profit, and academic organizations. The 2010 Regional Progress Report reviewed twenty new indicators rather than the original twenty-seven in the 2007 report. The new set of indicators is more closely related to the goals of the SGC, which is charged with implementing sustainable growth initiatives throughout the state. The new indicators allow for more consistent evaluation of sustainability programs across different state and regional agencies, and are in four areas: 1.) Efficient Transportation and Land Use, 2.) Economic Competitiveness and Opportunity, 3.) Environmental Health, and 4.) Resource Efficiency and Conservation. The report explicitly links these four areas to the three major components of sustainability, as illustrated in Figure 5-4.

One of the new economic indicators featured in the report is a green employment or green jobs indicator. In terms of transportation and land use trends, the indicators showed that individuals were driving less overall, but the individual decrease was negated by population growth which led to an overall increase in vehicle miles traveled and fuel consumption [4].

Data needs for the Progress Report are in two areas: land use

Data Need:

Built around 12 principles that explore the trade-offs among transportation planning, land use planning, housing needs, resource protection, and other crucial issues like greenhouse gas reduction

Data Sources:

-greenhouse gas emission levels (from fuel purchases/usage)
-percentage increase in residential density
-percentage reduction in acres of agricultural or green fields development
-percent jobs within quarter mile of transit station
-impacts to environmentally sensitive lands
External partners: Governor's Office of Planning and Research, the Department of Housing, and the Business, Transportation, and Housing Agency

Comments: **Data intensive with many measurable performance goals; limited quality-of-life goals; land use data limited in coverage area (reliant on local and regional partners)**

practices and equity. At a statewide level, there is a lack of complete land use data because of difficulties in coordinating across different state and local agencies. Robust equity measures are difficult to develop because of the gaps between Census data publication. With the rapid changes in the population, Census data quickly becomes out of date. The report calls for agencies and local governments to coordinate on defining sustainability and improving sustainability measurement, as well as to share successful strategies.

Figure 5-4. Regional Sustainability Framework (Source: California Regional Progress Report 2010)

Resources

[1] Caltrans. (2010). California Regional Blueprint Planning Program. < http://calblueprint.dot.ca.gov/>, (28 March 2010).

[2] California Center for Regional Leadership, Caltrans, California Association of Councils of Governments,
UC Davis. California Regional Progress Report 2007. <http://calblueprint.dot.ca.gov/index_files/CA_Regional_Progress_Report_2007.pdf>, (28 March 2010).

[3] Sacramento Area Council of Governments (SACOG). (2010). Sacramento Region Blueprint. <http://www.sacregionblueprint.org/technology/>, (30 March 2010).

CASE STUDY

NJFIT:

New Jersey Future in Transportation

Strategic Approach(es):

Collaboration

Integrity in Planning Process

Partner:

New Jersey Office of Smart Growth (OSG)

Brief Description:

Sustainability initiatives focusing on transportation and land use planning. Initiatives emphasize working with local communities and agencies to connect and develop existing transportation corridors. NJFIT's approach is intended to provide more transportation options and quality, and context-sensitive development while limiting tax expenditures and satisfying needs of all stakeholders.

Contact:
New Jersey FIT Program
njfit@dot.state.nj.us

What is the NJFIT Program?

The NJFIT program was started in the late 1990s in conjunction with the state's Office of Smart Growth as a Context Sensitive Design program. It was strengthened in 2005 by NJDOT's adoption of a Smart Growth Policy. NJFIT emphasizes re-investment in and transformation of roadways and transit centers using a variety of tools (see Inset) rather than construction of new facilities. NJFIT has led to three notable programs which have been recognized nationally for tackling coordination of transportation and land use for both roadway and transit projects.

Each of these three programs work towards a common set of goals established by the NJDOT. The main goal of NJFIT is to work alongside communities to connect local streets and design them according to CSD principles. By doing this, NJDOT accomplishes other goals like relieving traffic congestion and sprawl, providing affordable transportation alternatives, curtailing negative health effects of inefficient transportation systems, creating more jobs, and preserving and protecting natural resources (see Figure 5-5 for development principles). Instead of continuing to build new infrastructure, NJFIT follows the "Fix-It-First" Policy and

NJFIT "Toolbox" covers:

- **Problems and Solutions**
- **Sense of Place**
- **Environmental Resources**
- **Mix Land Uses**
- **Build For Transit**
- **Give Travelers Options**
- **Create More Connections**
- **Provide Better Access**
- **Design Roads in Context**
- **Calm Traffic**
- **Improve Communication**
- **Promote System Efficiency**

http://www.state.nj.us/transportation/works/njfit/toolbox/

renovates existing structures. This approach limits tax expenditures and saves time.

The first program, the Integrated Land Use and Transportation Corridors, was implemented in 1999. The program is a community-based initiative using visioning exercises to study the relationship between transportation projects and the surrounding built environment. The visioning results in corridor plans that are used to guide future decisions about the roadway design and development. The second program, also started in 1999, is the Transit Villages Initiative that involves coordination with ten other state agencies for "placemaking" around New Jersey's transit stations. The goal of the initiative is to revitalize communities by making transit facilities a focal point for both transportation and daily life. The Transit Villages Initiative operates with five principles in mind:

1. Mix residential, office, institutional, and other land uses;
2. Make streets friendly to bicyclists and pedestrians;
3. Build compact development;
4. Manage parking; and
5. Remember that transit-oriented development is not just for brand new development.

The newest initiative is the Mobility and Community Form program that was started in 2006 to provide guidance for municipal planning, visioning processes, and form-based codes (an alternative to traditional land use zoning). The NJFIT program and other smart growth initiatives are managed by the DOT's Office of Transportation and Sustainable Communities within the Statewide Planning Department. The office was created to leverage the technical expertise of both internal and external groups to create multi-modal, non-highway solutions to transportation problems and community development.

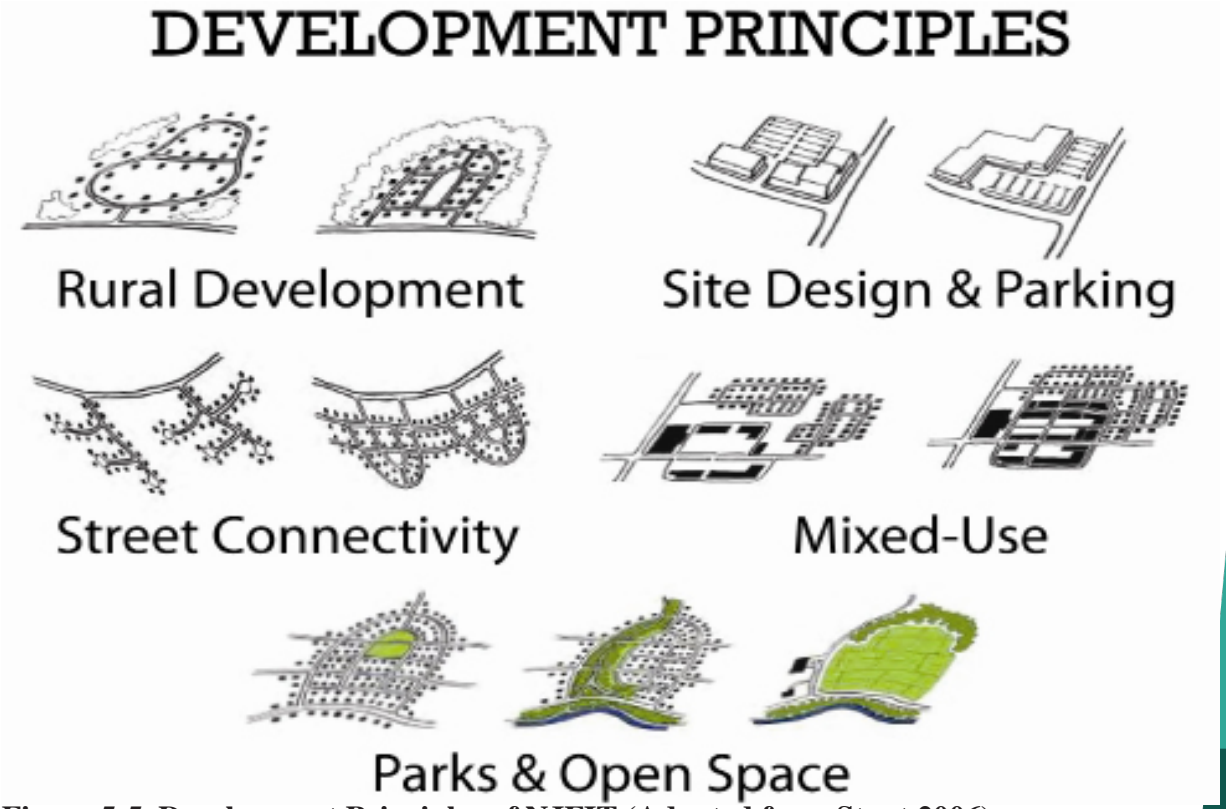


Figure 5-5. Development Principles of NJFIT (Adapted from Stout 2006)

Integrated Land Use and Transportation Corridors

After years of allowing transportation and community land use planning to evolve separately, the result has been widespread congestion, poorly connected transportation networks, and direct and indirect health problems. While there are many reasons why this approach has failed, NJDOT believes that there are four dominant factors that appear to be responsible [2]:

1. Higher road construction demands as individuals moved out of cities and into rural places;
2. Intentional division and separation of different types of land use;
3. Replacement of dense, grid-type transportation planning with disconnected, sparse planning;
4. Street designs customized to only fit the needs of an automobile.

In order to reverse the problems of congestion, NJDOT has committed to redeveloping existing infrastructure according to sustainable principles and context sensitive designs. As part of the Integrated Land Use and Transportation Corridors initiative, NJDOT created a set of design guidelines for the entire state and helped communities adapt the guidelines to their local context. Interested communities receive funds and expertise from NJDOT to support smart decisions. The goal is to help local planners understand the direction of future development in their community and then make effective, economical transportation decisions. By integrating transportation and land use planning, transportation solutions can be designed to respect the natural and built environment better [4].

In the early stages of the program, NJDOT applied an integrated land use and transportation approach to corridors where there was high congestion or accident levels. Success of the corridor plans paved the way for the other two NJFIT programs, and provided a standard for all future land use and transportation planning. Route 31 in Hunterdon County is an early example of a corridor plan completed as part of the Integrated Land Use and Transportation Corridors initiative.

Route 31- Hunterdon County, New Jersey: Land Use and Transportation Plan

Route 31 marks the beginning of one of the only North-South passageways in Hunterdon County, and was a major source of traffic in the 1980s. The five-lane roadway was designed to serve vehicles and was uninviting to pedestrians, bicyclists, and transit. Starting in 1987, NJDOT considered several congestion mitigation alternatives for the route. A standard interstate bypass was planned to relieve congestion and connect Route 31, Route 202, and the South Branch River in Hunterdon County. However, after the state established a set of smart growth principles in 2002, NJDOT reexamined this alternative and decided to adopt a more transit-oriented, context-sensitive, integrated planning process [1].

In order to involve the community, local officials, and other stakeholders in the development of Route 31, several forums were held including an advisory group, stakeholder interviews, design workshops, and public visioning sessions. The advisory group met regularly to provide initial direction for the study, review the plan's progress, and suggest changes. Stakeholder interviews were conducted to educate individuals about integrated transportation and land use planning and to gather their feedback on the Route 31 corridor plan. Collaborative work sessions with representatives from the NJDOT, the public, stakeholders, and the advisory group were held to discuss project alternatives. When alternatives and plans were drawn up, public visioning sessions were held to discuss the concerns and goals of the community as a whole. By providing multiple opportunities for public involvement, potential political

obstacles were averted and the needs of the community were represented [5].

After the community forums, several propositions were made to transform Route 31. In order to make it more pedestrian-friendly, to the plan proposed adding curb and gutter on both sides of the road to allow for street trees, and t for expanded and consistent sidewalk development. To satisfy visual aesthetics and traffic-calming measures, the plan proposed a contrasting pavement material in the middle left turn lane. Figure 5-6 illustrates several of the proposals for Route 31. By considering both transportation and land use motives simultaneously when planning to develop Route 31, an efficient alternative was created that will not only benefit vehicle drivers, but will satisfy pedestrians and bicyclists as well.

Existing Condition along Route 31

Route 31

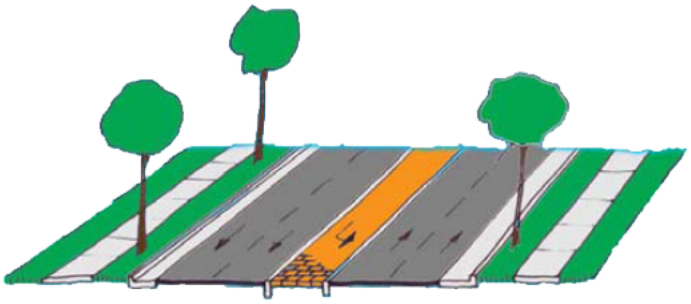
With the future South Branch Parkway providing an alternative to Route 31 through Flemington, the design of Route 31 in Flemington should be reconsidered.

Existing Condition
Route 31 is currently a 5-lane roadway (two lanes in each direction and a center left turn lane) with expanded shoulders. Very little attention has been placed on the pedestrian environment with no consistent pattern of sidewalks and/or street trees.

Proposed Cross Section
The Framework Plan envisions the opportunity to transform Route 31 into a more pedestrian-friendly commercial and residential corridor that can build upon and extend the character Flemington's Historic District and Main Street. To accomplish this, a future Route 31 is envisioned that maintains its 5-lane section while reconfiguring its edges to include consistent sidewalks and street trees.

- Curb and gutter on both sides of the road, allows for street trees and could be extended to accommodate bike lanes.
- Textured or contrasting material in the center left turn lane helps visually narrow the roadway and serves as a traffic calming measure.
- Tree lawn, street trees and sidewalks on both sides of the road creates a pedestrian-friendly environment.

Existing Route 31 Cross Section



Proposed Route 31 Cross Section

Figure 5-6. Proposed Changes to Route 31 (Source: HCPB 2008)

Transit Villages Initiative

The Transit Village initiative is a joint effort with NJ Transit that aims to revitalize communities, reduce traffic congestion, and improve air quality. These goals are achieved by utlizing existing infrastructure and public transit service to improve ridership. Municipalities that achieve designation as Transit Villages receive benefits such as priority funding and technical assistance from several state agences, and eligibility to receive planning grants from NJDOT. It also puts them in direct contact with the state DOT and other agencies, allowing them to expedite requests that would normally take longer periods of time. The process and criteria for designation as a Transit Village are depicted in Figure 5-7 [1].

Currently, there are 20 designated transit villages in the state of New Jersey. The City

of Orange received designation in 2009 and was awarded $100,000 for planning and design studies. NJDOT accepts applications on a rolling basis, and works with NJ Transit to assist municipalities that are interested in pursuing designation. Several New Jersey state agencies make up the Transit Village Task Force, which meets six times a year to review applications and decide how state funding will be distributed among the existing transit villages. South Orange is one of New Jersey's first transit villages, and demonstrates how the community capitalized on its long history of transit-oriented development.

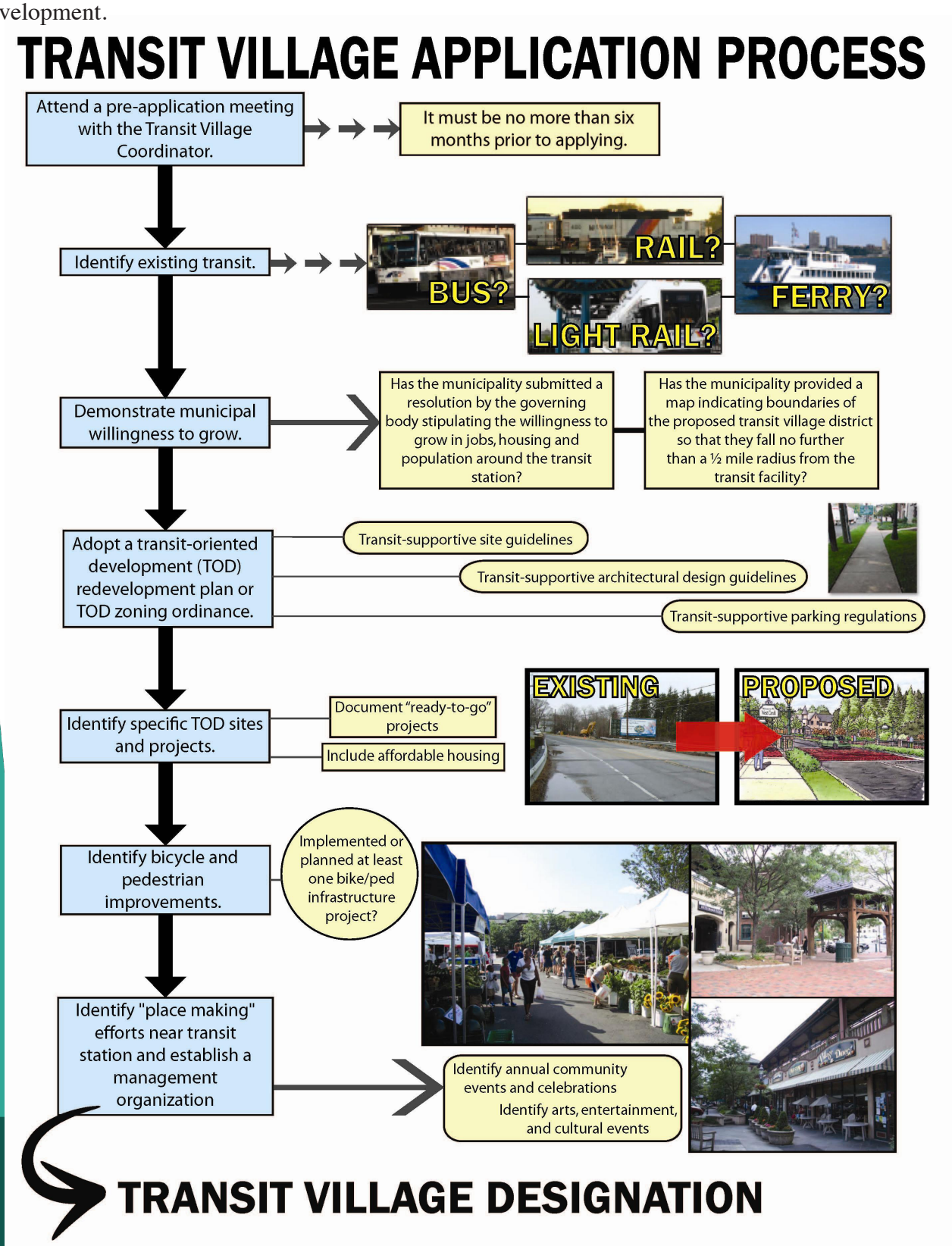


Figure 5-7. Transit Village Application Process (Adapted from NJDOT 2010)

South Orange Transit Village

The City of South Orange was designated as a transit village in 1999. The area has always been a center for mass transit, being built around the railroads in the late 19th century. Today, the NJ Transit Morris & Essex (M&E) line runs through South Orange, which has the 2nd busiest station on the M&E line, servicing approximately 3,450 riders on a daily basis [3].

After meeting the requirements for designation, South Orange took advantage of priority funding and grants to achieve its multi-modal vision (examples in Figure X). All of South Orange's residents live within one mile of the transit station, and Following Transit Village designation, the municipality encouraged a mix of housing types including apartments, condominiums, and senior living facilities to serve its residents, all of whom live within one mile of the transit station [3]. An extensive amount of bicycle pathways and storage racks have been placed in and around South Orange's downtown area. All day parking meters and streetscaping have been built to encourage walking. Historical landmarks, including firehouses and village halls, have been constantly renovated and restored in order to preserve the history and cultural context of the environment. Transit Village designation helped South Orange maintain its competitive edge. Since 1999, the municipality has attracted 33 new businesses and retained 8 others, creating jobs for its residents. In response to this development, the population has steadily grown and was projected to rise by 13% in 2030 [3]. For the past decade, South Orange has been working to become a model for future designated transit villages.

Mobility and Community Form

The Mobility and Community Form (MCF) program helps communities plan future transportation and land use. NJDOT published a Mobility and Community Form Guide (MCFG) to help communities create master plans for their future development designs. Emphasis is placed on connecting the communitiy to local facilities, buidings, and open space more effectively. Pedestrian and bicycle access are incorporated into land use patterns that also support public transit to help improve the quailty of life and raise sustainability [6]. The MCF program is aimed at moving away from traditional land zoning that allowed sprawl and poor transportation and land use planning to occur.

The MCFG specifies seven essential building blocks or "activity patterns" of urban form: circulation, shopping streets, parking, transit stops, neighborhoods, public places, and natural environment patterns (see Figure 5-8). For each of these patterns in community life, the MCFG has standards and guiding principles that each municipality should consider when creating their master plans. Each municipality is allowed to determine how their communities should be developed by creating design guidelines, called a Mobility and Community Form Element (MCFE), which customizes principles and regulations from the MCFG. An MCFE consists of three parts:

- Transects -- These illustrate the types of development patterns and accompanying social and economic activities in New Jersey, ranging from rural to urban),
- Patterns -- These provide design principles for each of the seven building blocks of urban form.
- Guides – These explain the process for linking transportation and land use in the municipal master plan.

ACTIVITY PATTERNS

CIRCULATION

- Multi-Use Streets – Design "complete streets" and intersections that serve pedestrians, persons with disabilities, bicyclists, transit vehicles, trucks, and motorists.
- Connectivity – Create interconnected street networks with frequently spaced intersections and networks of pedestrian paths and bicycle trails.
- Safety by Design – Encourage safe and predictable behavior by all road users. Road features should be designed to enforce desired speeds.
- Legibility – Provide a legible environment that helps users navigate and understand their surroundings.
- Sensitivity to Surroundings – Design bridges and roads in context, with respect to the surrounding environment.

SHOPPING STREETS

- Placemaking – Provide wide sidewalks with good lighting, shade, shelter, enclosure, transparency, seating, and visual interest.
- Anchoring – Foster strolling by creating places of interest at the ends of shopping streets.
- Multi-User Parking – Provide convenient, well-marking parking suitable for varied users: behind stops, on-street, or structured where appropiate; include parking for bicycles, sufficient handicapped spaces, and areas for truck deliveries.
- Safe Connections – Provide safe pedestrian connections for shoppers from parking areas, transit stops, and adjacent neighborhoods; provide effective, regularly spaced crossings on the shopping street.

PARKING

- Scale – Provide a realistic amount of parking for a given location; routinely include bicycle parking at trip destinations.
- Contextual Design – Design parking areas for pedestrian navigation and security; integrate them with surrounding uses; screen structures and lots though design features, landscaping, or placement behind buildings.
- Efficiency – Encourage shared parking and shared driveways.
- Loading and Delivery – Provide access and loading areas for truck deliveries.

TRANSIT STOPS

- Access – Provide for safe and convenient pedestrian and bicycle access to transit stops and stations.
- Identity – Make transit stops distinctive and recognizable from a distance.
- Comfort – Make each transit stop or station a comfortable, attractive, and inviting place to wait for the bus or train; encourage the provision of supportive activities and services.
- Supportive Densities – Encourage density of housing and employment around transit stations.

NEIGHBORHOODS

- Mixed Use and Housing Diversity – Create compact neighborhoods that combine homes of varied sizes with nearby land uses such as shops, workplaces, public buildings, and green spaces.
- Neighborhood Schools – Locate schools near neighborhoods where possible, and in all cases, create safe routes for children to travel to school.
- Pedestrian Access – Ensure that all destinations in a neighborhood can be conveniently reached on foot and all neighborhood streets can be crossed safely on foot or in wheelchairs.
- Street Scale – Street characteristics, including widths and design speeds, should be scaled to the type and palcement of neighborhood buildings.

PUBLIC PLACES

- Visibility and Framing – Make parks and plazas visible from adjacent streets. Use design features to frame and connect public places.
- Civic Cluster – Create access to shared civic space by grouping civic and institutional buildigns with pedestrian plazas or parks.
- Placemaking – Provide wide sidewalks or pedestrian paths with places to sit.

NATURAL ENVIRONMENT

- Access – Provide pedestrian and bicycle access to beaches, rivers, streams, meadows, and forests.
- Sensitivity – Design roads, bridges, and other transportation facilities in an environmentally sensitive manner, preserving scenic landscapes and natural terrain and protecting water sources.
- Boundaries – Plan transportation corridors that help define urban edges, reinforce natural boundaries, establish greenbelts, and protect fragile wildlife habitats.

Figure 5-8. Activity Patterns as defined by the Mobility and Community Form Guide (Adapted from NJDOT 2010)

The MCFE is used as a guideline for future development, and establishes a framework for new types of development codes.

Mobility and Community-

Design Guidelines for the Township of Edison

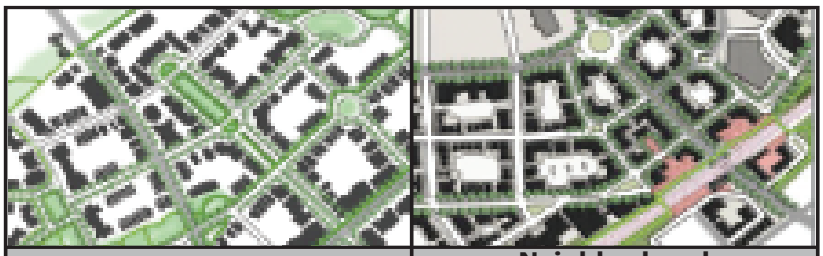
In 2007, the Township of Edison created a Mobility and Community Form Element to replace their traditional zoning regulations and requirements. The guidelines define their specific standards for all community or transportation projects that affect new or existing development, and provide directions for protecting and preserving open space and natural resources. By creating a single standard for all new development in the town, the community can grow consistently and more sustainably.

The community form section of the guidelines refers to the physical shape of development

and the patterns in which they occur throughout the community. These include block sizes, setback measurements, and parking lot layouts [7]. These aspects of development can be arranged in a variety of ways, and used to encourage or discourage different transportation and living activities [2]. Figure 5-9 provides an example of how detailed Edison's guidelines are. The guidelines even address the amount of transparency of windows on establishments and the direction in which parking structures and garages should face. The importance of planning and shaping the environment to suit the community's needs is paramount in the community's planning guidelines.

In addition to setting building standards, the guidelines also emphasize planning all travelways to meet the needs of more than just vehicles. Planning the travelways is crucial because travelways provide individuals with access to town amenities. The township of Edison realized the importance of integrating multi-modal travel options, and includes specifications in its guidelines for all sidewalks, crossings, driveways, bicycle facilities, and lighting features along its corridors. The specifications are customized to different roadway types or environments Figure 5-10 provides examples of planning specifications for the Edison Township.

Finally, Edison's guidelines also contain standards for developing areas of "open space": parks, green space, and recreational areas. The Township of Edison believes that planning open space is critical to successful mixed-use centers. They define open space in three ways: formal/informal, active/passive, and open/contained. It is also important that these civic, green spaces be customizable and multi-functional through the use of moveable seating to allow individuals to congregate and define their spaces personally [7].



Town Core	Neighborhood Residential
Thoroughfare Types	
Civic Avenue Community Avenue Neighborhood Boulevard Neighborhood Street	Community Avenue Neighborhood Boulevard Neighborhood Street
Block Length	
400'-600'	200'-400'
Setbacks (minimum + maximum)	
0-10'	0-25'
Parking	
Structured On-Street Interior Block Surface	On-Street Residential Alley
Mix of Uses	
Large Commercial (25-40%) Storefront Retail (25-40%) Civic (10-25%) Office (10-25%) Restaurant (10-25%) Multi-Family Residential (5-20%)	Single-Family Residential (25-75%) Multi-Family Residential (25-50%) Limited Retail (10-25%)
Massing	
2-8 Stories	1-3 Stories

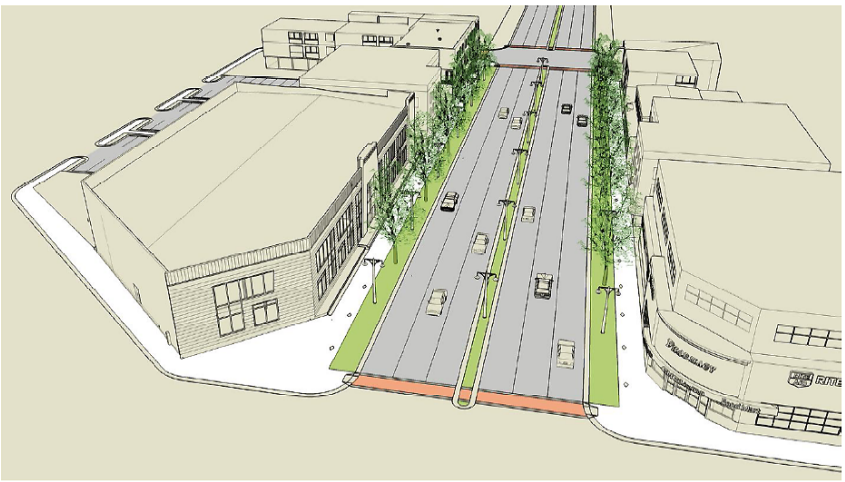
Figure 5-9. Design Standards by Community Type (Edison Smart Growth Planning Initiative 2007)

DESIGN ELEMENT: **REGIONAL ARTERIAL**

REGIONAL ARTERIAL

A regional arterial provides high-speed access between regional centers, as well as compact mixed use commercial and residential areas. The arterial serves both regional and local traffic, with an emphasis on through movements.

DESIGN SPEED: 45+ mph



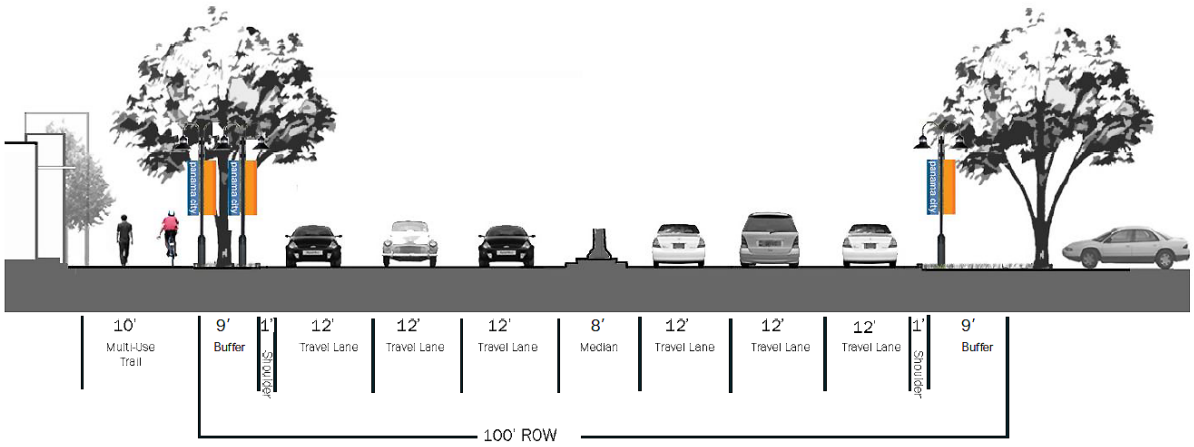


Figure 5-10. Design Standards for a Regional Arterial (Edison Smart Growth Planning Initiative 2007)

What has NJFIT achieved?

NJFIT has eight long-term goals:

- produce lively main streets,
- make sensible land use decisions,
- provide street designs for the entire community,
- make lasting investments,
- remain economically sound,
- enhance safety on the street,
- offer more ways to travel, and
- maintain healthy streets and communities [1].

NJDOT's case studies on the NJFIT website provide anecdotal evidence of progress made

on these goals. For example, South Orange, one of the first designated transit villages, successfully created a main street that accommodates both automobiles and pedestrians and promotes business interests. This was achieved by carefully integrated land use and transportation planning and considerable involvement [1]. Related to that South Orange's achievement, sensible land use decisions are linked with lasting investments that remain economically sound over time. Each NJFIT initiative weighs several alternatives over a long period of time to make sure that the greatest amount of open space is being conserved, and that the least amount of fiscal consequences and responsibilities will be incurred. Further, by utilizing existing infrastructure whenever possible, NJFIT initiatives have averted additional future construction and maintenance costs because there is no need to build new roads. Fixing existing roads and communities is much more affordable than having to build additional facilities [1].

Another sign of success is the popularity of the NJFIT programs. For example, the Transit Villages program steadily designated new communities and as of 2010 there were 20 official transit villages in the state. The program has been a model for other communities and other state DOTs to promote transit-oriented development. The success of New Jersey's transit villages can be measured by the growth in population, high level of community satisfaction, and amount of businesses flourishing in and around the developing areas. Much of the evidence of success is physical assets like new businesses, housing units, or sidewalk space. But in the long-term, NJDOT expects to see health benefits from promoting multi-modal transportation approaches.

Over time the NJFIT program has been refined by lessons learned from its projects. For example, public visioning exercises for Route 31 project revealed that the community had a very negative opinion of NJDOT. Since NJDOT had been promising to alleviate congestion on the corridor for more than a decade before the NJFIT program was established, the community had little faith in the agency. The community planning process showed that taking the time to build community trust and openly communicating are key elements for successful transportation planning. As a result of the Route 31 experience, NJFIT initiatives emphasize interacting with the local communities and educating the public, municipal staff, stakeholders, developers, and planning boards [5].

Data Need:

Measure program effectiveness with:
- **Value of grant funds**
- **Estimated annual costs of new construction authorized by building permits and property value changes within ½-mile of transit stations**
- **Annual changes in transit ridership**
- **Station area walkability**

Data Sources:

-GIS sources, municipal self reporting, state data sources on construction activity, property value data from state tax records, Econsult Corp. and the National Association of Realtors; and
-Administering surveys
-Walkability Audit - subjectively measure walking conditions around transit stations including Infrastructure/ Maintenance; Continuity; Traffic & Street Crossings; Streetscape & Pedestrian Amenities; Land Use; Security & lighting

Comments:

Performance measures allow direct impacts of program to monitored; Requires data from multiple public and private sources

Resources

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[8] Stout, Mark. (2006) "Linking Land Use and Transportation: NJ's Experience." New York Metropolitan Transportation Council (NYMTC). http://www.nymtc.org/download_file.cfm?filename=NJ%20Land%20Use%20Transportation%21-18-07.pdf> (March 31, 2010)

CASE STUDY

NYSDOT GreenLITES Certification Program

How does GreenLITES work?

In 1998 the U.S. Green Building Council introduced Leadership in Energy and Environmental Design (LEED), a green rating system for buildings. The LEED system, while not required, has led to marked improvements in the sustainability of buildings. LEED certification has become a great marketing tool for new developments due to positive public perception. In 2008, NYSDOT released a green rating system for transportation facilities and agency activities which is modeled after LEED. Different levels of NYSDOT, including planning and project development, design, construction, maintenance and operations, are implementing GreenLITES certifications tailored to their specific program areas [1].

GreenLITES Project-

Design Certification Program

In September 2008, NYSDOT introduced the first completed sustainability rating system for transportation projects. The GreenLITES Project Design Certification Program is a self-certification program. LITES refers to Leadership In Transportation and Environmental Sustainability. It is being used primarily for internal management for NYSDOT to measure performance, recognize good practices, and identify areas for improvement. The program will also provide a way for NYSDOT to demonstrate sustainability achievements to the public. NYSDOT project designs submitted after September 25, 2008 will be evaluated for sustainable practices based on a points system and receive a certification level. Approximately 250 points will be available in five categories: Sustainable Sites, Water Quality, Materials and Resources, Energy and Atmosphere, and Innovation/Unlisted. Because this system extends beyond just road projects, not all credits will be available for each project, thus there is a large number of credit opportunities. Certification levels are as follows:

- Non-certified: 0-14 points
- Certified: 15-29 points
- Silver: 30-44 points

Strategic Approach(es):

Collaboration
Integrity in Planning Process

Brief Description:

Internal rating system for DOT projects, operations and maintenance, and planning to recognize sustainable practices and innovation.

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- Gold: 45-59 points
- Evergreen: 60 or more points.

Certification levels were in part established by analyzing 26 completed DOT projects. For example, 33 percent of the recently completed projects would not have been certified and only two percent (one project) would have received Evergreen certification, indicating that the levels were properly calibrated to encourage innovation [1,2].

GreenLITES is designed to be flexible and will evolve over time as new sustainability practices are developed. Project certifications will be recognized internally and also presented in an annual report to the DOT Commissioner. On Earth Day 2009, NYSDOT issued a press release announcing its first set of certifications and recognizing four Evergreen and six Gold rated projects, and stated that the rating system is being adopted by the State Thruway and Bridge authorities [3]. While the project rating system was developed for DOT projects, other New York State government agencies and authorities, local municipalities, and non-governmental organizations (NGOs) can complete the GreenLITES scorecard and request certification for federally funded local transportation projects.

GreenLITES Operations Certification Program

The GreenLITES Operations program launched on Earth Day 2009 and is designed to recognize and increase awareness of sustainable methods and practices already incorporate into NYSDOT's daily operations and to expand use of those practices and other innovative alternatives to improve transportation sustainability. Like the Project Design Certification, the Operations Certification will be an internal management program to measure performance, recognize best practices, and make improvements. It also provides a way for the DOT to communicate with the public about progress it is making in transportation sustainability. The Maintenance and Operations Plan (MOP) GreenLITES scoring system will assess the extent to which sustainable operations projects and practices are incorporated into Maintenance Residencies, Regional Bridge Maintenance Groups, Main Office and Regional Operations Program Areas. Each group has specified categories that they will be scored on. A score is based on the number of points achieved over the total number of points available in a category. For example, the Bridges Program will rate "Use environmental protection during bridge repair" by the number of bridges receiving the treatment compared to the number of eligible bridges. Certificates (based on points earned) will be available for Residencies and Regional Bridge Maintenance Groups and Special GreenLITES awards will be available for innovations in Main Office and Regional Operations Program Areas. The certification levels are as follows:

- Certified: Incorporated a number of sustainable choices.
- Silver: Incorporated a number of sustainable choices with several having a high level of impact or advancing the state of practice.
- Gold: Incorporated a substantial number of sustainable choices with many of these having a high level of impact or advancing the state of practice.
- Evergreen: Incorporated the highest number of sustainable choices with many having a high level of impact. The group or program also advanced the state of practice or was innovative in the way environmental sustainability was approached in operations.

NYSDOT is using the trial year (2009-2010) to calibrate initial certification levels. All of the scores for the first year will be divided into thirds representing low, medium, and high levels of environmental sustainability. The lowest third will not receive certification, the middle third will be certified, and the upper third will be distributed among Silver,

Gold, and Evergreen (see distribution in Figure 5-11). As progress is made on sustainability, NYSDOT expects that program scores will begin to skew to the right as operations groups make more and more sustainable choices. To maintain the applicability of the scoring thresholds, certification criteria will be adjusted to reflect that progress. For example, new best practices and innovative approaches will be incorporated into the scoring system whereas practices that become commonplace (like energy efficiency in buildings) will be removed.

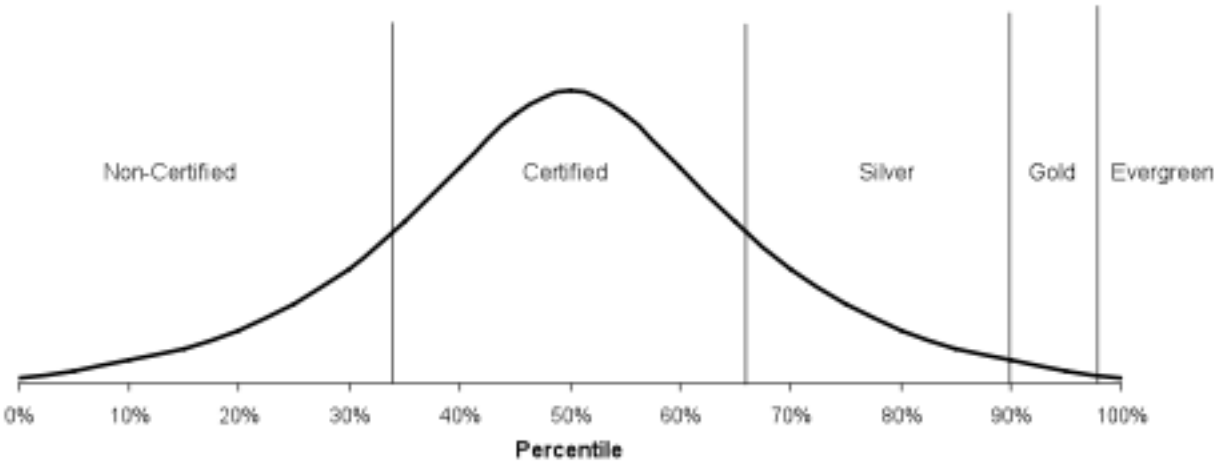

Figure 5-11. Proposed initial GreenLITES certification distribution. (from GreenLITES 2010)

Examples of GreenLITES Evergreen Certified Design Projects

The first set of GreenLITES awards recognized four Evergreen certified projects, representing the most sustainable and innovative projects [4]. The projects include three highway projects and one greenway/multi-use trail. The first project was a three-mile highway reconstruction of New York State Route 30/Ski Tow Road in Tupper Lake, Franklin County. The highway is located along the Adirondack Trail Scenic Byway and borders Tupper Lake, forest preserve, and environmentally sensitive wetlands. The project included multiple examples of environmentally and socially sustainable design elements:

- Widening to improve shoulder width balanced needs of traveling public and of environmentally sensitive Adirondack ecosystems.
- Embankment slopes were steepened along the causeway segment to avoid and minimize impacts and fencing was installed along wetland borders to protect turtles from the trafficway.
- Relocating utility lines underground enhanced the view shed in three locations along the highway, and four parking locations along the route allow the public to enjoy the designated scenic vistas.
- A closed storm drainage system was constructed to capture sediment and reduce migration of pollutants into the lake.

The second project addressed congestion on Route 85 in a way that was compatible with the Town of Bethlehem's comprehensive plan. The primary components were a 1.5 mile bypass (four lane divided highway) and three roundabouts, but the project also included widening of a bridge and construction of a bicycle pedestrian bridge over a stream. Environmental sustainability features included:

- Roadway design that provides a buffer between the roadway and historic properties and natural water resources.

- A depressed design to minimize physical and visual effects on existing buildings.
- Using roundabouts to meet traffic demands while lessening fuel consumption and emissions of a traditional intersection.
- Using local soil, native vegetation, stormwater mitigation basins, and 2:1 wetland mitigation to protect and enhance the natural environment.

The third project is the Buffalo Outer Harbor Parkway, which includes the reconstruction and resurfacing of 2.5 miles of New York Route 5, four new bridges, a new complete diamond interchange, and reconfigured on/off ramps. The project also includes reconstruction of 3 miles of Fuhrmann Boulevard into a two-way facility along the waterfront, construction of two roundabouts, and a multi-use path network. The project's design incorporates the unique industrial heritage of Buffalo and the beauty of the Lake Erie Ecosystem to transform the waterfront into a recreational destination. Specific environmentally sustainable practices include:

- Reducing the overall pavement area and thus impervious area by downsizing Fuhrmann Boulevard.
- Recycling existing on-site concrete and reusing 100-year old roadway cobbles as roadway sub-base and pathways.
- Construct or improve structures for wildlife passage under New York Route 5.

The final project receiving Evergreen certification was the Bronx River Greenway, which is a 23-mile multi-use path paralleling the Bronx River. The Greenway will restore and redevelop over 25 acres of open space and provide community amenities like soccer and softball fields, children's playground, picnic areas, over 2 miles of passive paths, and floating docks. Environmental and social sustainability features include:

- Naturalizing 3.2 acres of former industrial land use, including conversion of over 100 feet of bulk headed water front into naturalized river edge with native plantings and wetlands.
- Drainage system including rain gardens that will capture, filter, and store rain water to irrigate planted native vegetation.
- Removal of 18 acres of invasive species to ensure survival of native plants.
- Restoration of a historic railway catenary tower to demonstrate the historic significance of the railway.
- Multi-use path, one-kilometer walking loop, and new pedestrian bridges to promote physical activity and community enjoyment of the Bronx River system.

Assessing Outcomes and Future Directions

As mentioned previously, a primary purpose of the program is internal performance monitoring. The Engineering Division and Office of Operations are developing GreenLITES performance measures that will be collected annually and compared against baseline data to assess achievement of performance goals [1,2]. After a baseline is established in the first year of each GreenLITES program, the Commissioner and appropriate directors will establish annual performance goals. Implementation of a GreenLITES Regional Assessment Rubric is scheduled for Earth Day 2011. It will assess all projects, residencies, and activities across the DOT's regions, and will represent an expansion of the program to

include more transit, pedestrian, and rail projects. GreenLITES is also being incorporated into the planning process by including sustainability goals in long range plans and the development of the Department's capital program. At the local level, NYSDOT has introduced a Project Solicitation Tool that allows project sponsors to review and rate the sustainability of proposed transportation projects.

Another purpose of GreenLITES is promoting sustainability to the public. By reporting results and progress on Earth Day, NYSDOT is linking GreenLITES to an annual event. The public, local officials and DOT personnel will come to expect annual reporting, encouraging future leadership to maintain the GreenLITES program as a key monitoring and outreach tool.

In addition to its effects on NYSDOT, GreenLITES is influencing sustainability practices at other transportation agencies. Illinois DOT modeled its Illinois – Livable and Sustainable Transportation (I-LAST) Rating System after the GreenLITES system, and the Pennsylvania Turnpike Commission adapted GreenLITES to analyze the design and construction phases of new or expanded facilities.

Resources

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[3] NYSDOT Office of Communications. (2009). State Transportation Commissioner Glynn Celebrates Earth Day: Announces GreenLITES Expansion & Adoption by Thruway and Bridge Authorities. Press Release April 22, 2009, <https://www.nysdot.gov/news/press-releases/2009/2009-04-22>, (28 May 2009).

[4] NYSDOT. (2009). 2008 – 2009 GreenLITES Evergreen Project Summaries . <https://www.nysdot.gov/programs/greenlites/repository/2008-09%20Evergreen%20Certified%20Projects%20Summaries.pdf>

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Data Need:

Evaluation criteria for:

- **Projects - sustainable sites, water quality, materials and resources, energy and atmosphere, and innovation**
- **Planning – consistency with comprehensive plan, livability principles, environmental enhancement, economic benefits, et cetera**
- **Operations – maintenance and operations activities for different types of infrastructure (e.g. pave with recycled asphalt or LED highway lighting upgrades)**

Data Sources:

Project and Operations certification requires DOT generated data for the aforementioned evaluation criteria; Planning (project selection) uses a checklist that will be completed by project sponsors, so will require data entry.

Comments: **Data intensive; difficult to compare results with other state DOTs as similar systems do not exist in other states; First need to define "credits" or evaluation criteria, which requires identifying best practices – likely need external data (materials, processes, etc.)**

CASE STUDY

WSDOT Gray Notebook

Strategic Approach(es):

Education

Brief Description:

The "Gray Notebook", so called for its gray cover, provides a quarterly, in-depth report of goals and measures and a "Performance Dashboard" of key indicators. In addition to informing DOT staff, the Gray Notebook also provides accountability to the state government and citizens. It can be combined with WSDOT's Sustainability Plan to provide a framework for monitoring the sustainability performance measures.

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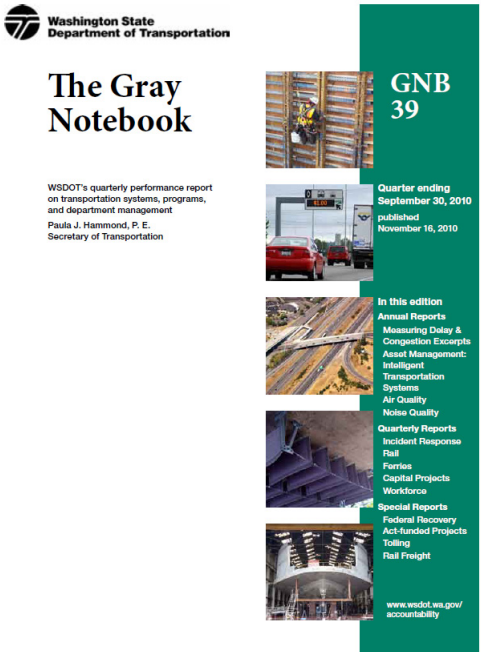
WSDOT believes that their performance management and accountability program will help achieve a transportation system that is:

- Reliable with improved travel times for drivers, more choices for travelers, and increased inter-city transit opportunities.
- Responsible with safer roads and fewer fatalities and serious injuries; cost-effective asset management and preservation; more integrated highway, transit, and ferry travel options; and increased special needs transportation and access to jobs and lifeline services.
- Sustainable through cleaner air and water, a strategic and balanced approach to climate change, predictable funding, and affordable improvements and operations.
- Trustworthy with honest, no-surprises reporting and demonstrated commitment to open and accountable business practices to both citizens and government. [1]



What is the Gray Notebook?

WSDOT started publishing Measures, Markers, and Mileposts (or the "Gray Notebook") in 2001 and released its 35th Edition in November 2009. The Gray Notebook (GNB) is published in February, May, August, and November, and provides in-depth reports on DOT and transportation system performance. It is a tool for internal monitoring and for public and legislative communication. The GNB's sections are organized around WSDOT's five legislative and strategic policy goals, which reflect sustainable transportation principles:

1. Preservation: To maintain, preserve and extend the life and utility of prior investments in transportation systems and services.
2. Safety: To provide for and improve the safety and security of transportation customers and the transportation system.
3. Mobility: To improve the predictable movement of goods and people throughout Washington state.
4. Environment: To enhance Washington's quality of

life through transportation investments that promote energy conservation, enhance healthy communities and protect the environment.

5. Stewardship: To continuously improve the quality, effectiveness and efficiency of the transportation system.

Performance measures are linked to each of the goals. Annually, WSDOT reports on over 100 measures that cover all key agency mandates, functions, and transportation modes. Based on data collection and availability, some performance measures are reported each quarter while others are reported annually. Each section of the GNB includes project narratives, performance measure reports, and charts and tables [1,2,3].

Hard copies of the GNB are distributed to about 2000-3000 subscribers, including all legislators, the Governor, the Transportation Commission, interest groups, city and county governments, national academic and research organizations, national partners, AASHTO members, and international colleagues. Additionally, WSDOT takes advantage of its website to distribute the information to citizens and other interested parties. The agency also maintains an online archive of all past GNBs and a Performance Measurement Library [4]. The Library provides agency and external colleagues access to other state DOTs' performance reports, supplements to the GNB and relevant, up-to-date national and international research on performance topics.

What is unique about the Gray Notebook?

The GNB evolves over time to account for new challenges or priorities. For example, WSDOT incorporated stimulus tracking into the GNB, going above federal requirements for accountability. As another example, WSDOT has collected data on congestion since 1988. Following the Legislature's creation of the five policy goals in 2007 (including Mobility–Congestion Relief), the agency included congestion reporting in the GNB and began publishing the Annual Congestion Report as part of the September edition. In addition to demographic and economic indicators, the Congestion Report tracks vehicle miles traveled and congestion, hours of delay, and cost of delay on state highways. It also reports corridor specific congestion indicators for the Puget Sound Region and data on WSDOT's congestion relief projects and the Moving Washington program, which coordinates all of WSDOT's congestion mitigation efforts (see Case Study on WSDOT's Climate Change Initiatives, page 134). As a final sign of evolution, the Sustainability Plan includes numerous measures to track progress on meeting targets, some of which are already included in the GNB. WSDOT is in the process of devising measures for transportation emissions to include in the GNB [5,6].

In addition to metrics, performance management at WSDOT includes state-of-the-art performance assessments of projects and programs, referred to as "before and after" studies. The studies verify that intended results were achieved and help staff learn how to improve results in the future. For example, WSDOT has installed 181 miles of cable median barriers on divided highways since 1995 to improve safety. Additional cable barriers are being installed using Federal economic Recovery Act funds (ARRA). WSDOT's before and after analysis of data for over 15,000 collisions indicate that cable median barriers have reduced the rate of serious and fatal injury collisions in or across the median by 58%. Based on this work, WSDOT is evaluating cable median barrier applications to highways with medians greater than 50 feet [1].

Besides improving content, WSDOT has also made the GNB even more user-friendly over the years. The Performance Dashboard was first included in June 2008 to highlight key performance measures for each strategic goal. It shows the current and previous

performance mark for each measure, indicates which way the program is trending, and offers an explanation for the trend (illustrated in Figure 5-12). WSDOT started publishing GNB Lite in 2004, which provides a 6-page excerpt of selected performance topics and project delivery summaries from the 100-page Gray Notebook. The quarterly publication of the GNB Lite is more manageable for politicians and citizens to digest.

Performance Dashboard

✓ Goal has been met. ↑ Performance is trending in a favorable direction. ↔ Trend is holding. ↓ Performance is trending in a unfavorable direction.

Policy goal/Performance measure	Previous reporting period	Current reporting period	Goal	Goal met	Progress	Comments
Safety						
Rate of **traffic fatalities** per 100 million vehicle miles traveled (VMT) statewide (annual measure, calendar years: 2008 & 2009)	0.94	0.87	1.00	✓	↑	The rate of highway fatalities continues to decline (a lower rate is better)
Rate of **strains and sprains / hearing-loss injuries** per 100 WSDOT workers[1, 7] (quarterly measure: FY10 Q4, FY11 Q1)	2.2/ 0.7	2.5/ 0.5	2.4/ 0.4	–	↓	Both strains/sprains and hearing-loss just barely missed their goals for the quarter
Preservation						
Percentage of state **highway pavements** in fair or better condition (annual measure, calendar years: 2007 & 2008)	93.3%	94.0%	90.0%	✓	↑	Recovery Act-funded projects are contributing to reductions in "due" rehabilitations
Percentage of **state bridges** in fair or better condition (annual measure, fiscal years: 2009 & 2010)	97.0%	98.0%	97.0%	✓	↑	Recovery Act funds contributed to increase in Good/Fair rating
Mobility (Congestion Relief)						
Highways: annual weekday **hours of delay** statewide at **maximum throughput speeds**[2] (annual measure: calendar years 2007 & 2009)	32 million	25 million	N/A	N/A	↑	Reduction of 21% as a result of reduced demand due to the economy, and increased capacity
Highways: Average clearance times for **major (90+ minute) incidents** on 9 key western Washington corridors[7] (quarterly: FY10 Q4, FY11 Q1)	151 minutes	154 minutes	155 minutes	✓	↓	One 11-hour extraordinary incident affected the program's average clearance time this quarter.
Ferries: Percentage of trips departing on time[3, 7] (quarterly, year to year: FY10 Q1, FY11 Q1)	86%	83%	90%	–	↓	None of the routes met the goal; new evaluation program underway
Rail: Percentage of Amtrak *Cascades* trips arriving on time[4, 7] (quarterly, year to year: FY10 Q1, FY11 Q1)	71%	73%	80%	–	↑	WSDOT and Amtrak continue to evaluate projects and other means to improve on-time performance
Environment						
Cumulative number of WSDOT **stormwater treatment facilities** constructed or retrofitted[5] (annual measure: calendar years 2008 & 2009)	Over 800	Over 1,037	N/A	N/A	↑	Stormwater facilities will now be constructed under a new permit, with new requirements
Cumulative number of WSDOT **fish passage barrier improvements** constructed since 1990 (annual measure: calendar years 2008 & 2009)	226	236	N/A	N/A	↑	Ten additional retrofits were completed in 2009

Figure 5-12. Snapshot from the September 2010 Gray Notebook's "Performance Dashboard" (Available at http://www.wsdot.wa.gov/accountability/graynotebook.pdf)

Aside from the substantial content, the report is presented in a unique way. WSDOT uses a style of reporting that it calls "Performance Journalism." This style was created by the agency after its first six years of experience with performance reporting. Performance Journalism combines effective narrative writing with visual graphs, tables and measurements in order to provide a clear and accurate assessment to the widest possible audience. The goal is to share the performance of WSDOT's most complex and diverse programs and projects

clearly and concisely in a format that everyone can easily understand and explain to their neighbors. This type of communication requires a collaborative effort between the production staff, data analysts, and program experts across the agency. The seven principles of Performance Journalism are:

1. Good Stories Combined With Good Graphics - Use narrative reporting to make it real and tell the story
2. Good Writing - Use a reader friendly approach
3. Good Data -Unyielding pursuit for data integrity and quality
4. Good Graphics -Every graph tells a story, every graph asks a question
5. Good Format/Presentation - Design should not distract from content
6. Quality Control - It's your credibility; it is part of every step in the analysis and report production
7. Good Timing -Lead, don't follow; provide frequent and timely information.

How has the Gray Notebook helped WSDOT?

The Gray Notebook has led to important internal and external outcomes. Internally, system indicators are tracked and the DOT tries to determine what causes an indicator to change so that corrective or preventative actions can be taken. This performance monitoring helps agency executives and senior managers with decision making. Progress towards achievement of strategic goals has been reported throughout the agency. Performance measurement has become part of the culture at WSDOT because producing the GNB necessarily involves conversations among staff about performance. The importance of performance measurement to WSDOT is expressed by the motto "What gets measured, gets managed."

Externally, the largest impact of such transparent measuring and reporting of performance results was the increased confidence of the Governor, Legislature and public in the projects and programs managed by WSDOT. In particular, public opinion changed. When asked if they trusted WSDOT to spend tax dollars wisely, nearly 75% of voters said no in 2001, but by 2004, 88% said yes. As a direct result of performance management, the Legislature approved gas tax increases in 2003 and 2005 that have supported the largest transportation construction program in the state's history, amounting to around $16 billion. Further, a citizen initiative to repeal the 2005 tax increase was rejected by voters [1,3].

Though the GNB has received consistently positive feedback, WSDOT continuously seeks to improve its monitoring and presentation of data. The agency looks to national and international peers for best practices in performance reporting. For graphing guidance, WSDOT relies on the work of Yale University's Professor Edward Tufte, whose research and publications on graphics have been widely adopted in business and government. Tufte's principles have helped WSDOT deliver clear graphical interpretations of performance data [7].

From its years of experience, WSDOT offers "lessons learned" for other agencies looking to start or refine a performance management program. Examples include:

- Start small but report now – do not delay until you have the perfect data, the right measurement framework or a sophisticated IT system. It is vitally important to build performance measures incrementally over time to establish a solid foundation and a track record of success.

- By making performance measures useful, and using them, the benefits of performance management and accountability outweigh the costs of collecting and analyzing data.
- There is no "one-size-fits- all" system or measure. Sometimes multiple measures are needed to clearly analyze service delivery. And measures need to be dynamic to respond to changing political or fiscal environments.
- Performance targets should be based on current conditions, federal funding levels, and what is achievable. Entities that deliver transportation services are in the best position to establish meaningful targets in collaboration with their federal partners.
- Focus on long-term trends, not short-term targets.
- Continuously learn from others and adapt their good ideas.
- Do not measure for measures' sake – choose meaningful measures that reflect what is happening in the system and what the public and lawmakers care about.
- Performance measures can demonstrate the effects of programs and how taxpayers benefit from them, and can make a case for continued funding.
- Timing is everything – deliver information in a timely manner.
- Make relevant and easy-to-understand communication through measures, text, and graphs your number one priority, not an afterthought once the data is collected.
- Apply strict standards of quality control for data and writing at all levels of management. Your data and analysis is your credibility.
- Hold regular problem-solving sessions with key management.
- Executive management support and hands-on involvement is paramount for establishing buy-in from other staff.
- Developing and reporting good measures, and engaging in solid analysis, takes time, ongoing management commitment, and consistent allocations of staffing and data management resources.

Additional lessons are offered in "History of Performance Measurement at WSDOT" and "Performance Management and Accountability at WSDOT" [1,3]

Data Need:

Book provides quarterly, in-depth report of goals and measures and a "Performance Dashboard" of key indicators; Over 100 measures are taken to gage the legislative and strategic goals: preservation, safety, mobility, environment, and stewardship

Data Sources:

Internal DOT monitoring

- **Congestion reporting at WSDOT: average travel times recorded semi-annually, peak volumes**
- **Before and after accident records**

External source such as EPA used for climate change monitoring

Comments: **Data intensive; very little use of external data and few quality-of-life measurements conducted; information is presented in a clear and easy-to-read format**

Resources

[1] WSDOT. (2010).“Performance Management and Accountability at WSDOT.” http://www.wsdot.wa.gov/NR/rdonlyres/024555DA-3CAD-4793-8FD9-8BF1CF4A6D07/0/2010_WSDOT_PerformanceManagement_Folio.pdf

[2] WSDOT. (2010). Accountability and Performance Information. Available at <http://www.wsdot.wa.gov/accountability/>

[3] WSDOT. (2008). “History of Performance Measurement at WSDOT”. January 2007 (Updated June 2008). Available at <http://www.wsdot.wa.gov/NR/rdonlyres/91089378-E709-49EF-AE42-AE80BC44A91C/0/TRB_Performance_Folio.pdf>

[4] WSDOT. (2010d). Performance Reporting Library. Available at <http://www.wsdot.wa.gov/Accountability/Publications/PerformanceDocuments>

[5] WSDOT. (2009). 2008 Sustainability Plan and Progress Report Update. Available at <http://www.wsdot.wa.gov/NR/rdonlyres/A66BD61B-0CB7-48F3-9403-D2542CE2B7E5/0/2008SustainabilityPlanandProgressReportUpdate_091409_final.pdf>

[6] WSDOT. (2010b). Congestion Reporting at WSDOT. Available at <http://www.wsdot.wa.gov/Accountability/Congestion/>

[7] Tufte, Edward. (2001). The Visual Display of Quantitative Information, 2nd edition. Graphics Press, Cheshire, Connecticut.

CASE STUDY

ODOT

Investment Scenarios

How does ODOT use the Policy and Investment Scenarios?

Strategic Approach(es):

Sustainable Funding

Brief Description:

Oregon Transportation Plan assesses seven policy scenarios and three investment scenarios to determine system performance outcomes of different levels and types of investment.

With competing goals and declining funds, Oregon Department of Transportation (ODOT) needed a way to investigate the impacts of its investment decisions and establish key strategies for implementing the Oregon Transportation Plan. ODOT analyzed seven system scenarios and then packaged them into three investment scenarios. The scenario analysis allowed ODOT to consider both system impacts and broader sustainability implications.

The Oregon Transportation Plan, adopted in September 2006, assesses seven policy scenarios and three investment scenarios to determine how the level and type of investment will impact system performance. Based on a needs assessment, ODOT determined funding priorities and three types of scenarios: a reference scenario, sensitivity scenarios, and policy scenarios. The reference scenario included projects that could be funded if the DOT's purchasing power remained level through 2030. It was used as a baseline for comparison with the other six scenarios. The two sensitivity scenarios considered the impacts of increasing fuel prices and relaxing land use policies. The four policy scenarios (flat funding or decreasing purchasing power, maximum operations, major improvements, and pricing) examined impacts of potential transportation policy decisions involving revenue levels, sources, and priorities. The scenarios were assessed based on eight criteria: (1) mobility and accessibility, (2) economic vitality, (3) effectiveness and efficiency, (4) equity, (5) public support for the system and financial feasibility, (6) reliability and responsiveness, (7) safety, and (8) sustainability. Potential impacts were analyzed by mode to determine whether there had been improvement or decline over time. Table 5-5 shows a summary of this analysis for the reference scenario.

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Table 5-5. Reference scenario impacts over time by mode from OTP 2006.

Performance Criteria	Passenger Surface Transportation	Trucking	Rail Freight	Aviation	Ports
Mobility	▼	—	▼	—	▼
Accessibility	—	▼	—	—	▼
Economic Vitality	▲		▼	—	▼
Effectiveness & Efficiency	—	▲[32]	▼	—	—
Reliable	—	—			
Equity	—	—	—	—	▼
Safety	—	—	▼		
Sustainability	—		▼	—	▼
Public Support and Financial Feasibility	—	—			

▲ Improves over time; — No change over time; ▼ Worsens over time

[32] Based on a measure of VMT per ton

The analysis revealed important findings for each scenario:

- Reference Scenario: Funding would keep up with inflation but only allow for a few annual capacity-enhancing projects. Congestion and travel times for both vehicles and rail freight would increase state-wide.
- High Fuel Price Scenario: Higher fuel prices could lead to changes in mode choice for some trips and to an overall reduction in trip making. This trend could reduce travel times and congestion but would lead to a decline in economic activity statewide. Air travel would experience significant negative effects. The Portland region would be less affected than other regions because of its large size, more compact development pattern, and availability of alternate forms of transportation.
- Relaxed Land Use Scenario: Increased availability of land for development along the urban fringe and in rural areas would have minimal impact statewide because of a sufficient land supply within urban growth areas. At the local level, a less compact development pattern could not be supported by existing infrastructure.
- Flat Funding Scenario: A flat level of funding would reduce purchasing power by up to 50 percent by 2030. Without new funding sources, the DOT would not be able to invest in necessary transportation capacity projects or in rail and marine infrastructure to boost the economy. Roadway and bridge conditions would deteriorate and long-term maintenance costs would rise.
- Maximum Operations Scenario: Making highway operational investments and enhancing local transit services would lead to considerable gains, especially in metropolitan areas. In the Portland area in 2004, increasing frequency of transit services saved 28 to 40 percent of delays while highway operational strategies saved 10 percent.
- Major Improvements Scenario: Funding major improvement projects on the state's highway network would lead to travel time reductions. Further, highway and freight rail capacity improvements in the Portland area and the Willamette Valley would positively impact state economics by providing better connections to commercial centers.
- Roadway Pricing Scenario: Implementing road pricing strategies statewide would lead

to the greatest reductions in travel times and congestion, and in large urban areas, tolled facilities could cover operating costs.

Results of the policy scenario analysis influenced creation of the implementation and investment plans. In particular, the investment framework includes three investment scenarios (see Figure 5-13 below) that illustrate how the publicly-supported transportation infrastructure and services would respond to different levels of funding. The investment scenarios are combinations of the policy scenarios discussed above. The three scenarios are:

- Level 1, Response to Flat Funding: combines elements of the Flat Funding and Maximum Operations scenarios to assess the adjustments that will be necessary if no additional transportation funds become available. Level 1 emphasizes preservation and operational improvements to maximize system capacity.
- Level 2, Maintaining and Improving Existing Infrastructure and Services: combines elements of the Reference and Maximum Operations scenarios to preserve existing facilities and services and keep up with inflation.
- Level 3, Expanding Facilities and Services: combines elements of the Major Improvements, Pricing, and Maximum Operations scenarios to represent the funding level required to keep pace with travel growth and to increase transportation system capacity to meet feasible needs. Feasible needs means replacing infrastructure and equipment, bringing facilities up to standard, or adding just enough capacity so that the system runs slightly more optimally than it currently does.

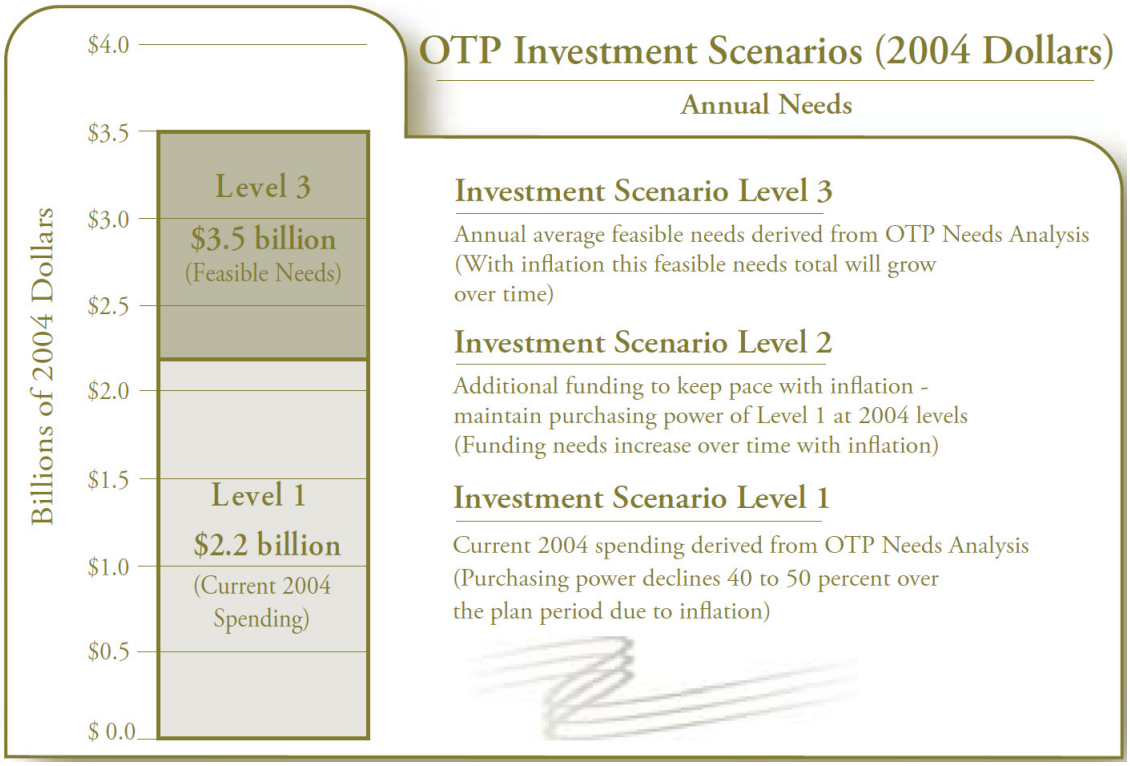

Figure 5-13. Illustration of Oregon DOT's three funding scenarios. (Source: http://www.oregon.gov/ODOT/TD/TP/docs/ortransplanupdate/ExecutiveSummary.pdf)

System impacts by transportation sector were analyzed for each of the investment scenarios in terms of maintenance, preservation, operations, and system expansion. Analysis revealed that Level 1 or 2 investments would not meet the state's needs for livability and economic vitality. In particular, Level 1 would not even maintain existing infrastructure conditions

and services. Level 2 would not be sufficient to relieve highway bottlenecks and keep up with capacity needs of rapidly growing regions. As a result, the OTP recommended pursuing Level 3 investment. In order to overcome the $1.3 billion annual funding gap between Level 2 and 3, the state would take incremental steps over time based on available funding sources (traditional and new).

How have the scenarios impacted decision-making?

ODOT developed the policy and investment scenarios to quantify potential impacts of transportation decisions on infrastructure conditions and the state's economy. Investigating trade-offs among the different scenarios helped decision-makers identify priorities and establish key strategies for implementing the OTP. In particular, the performance gap between Levels 2 and 3 provided a strong argument to pursue new funding options like road tolling or public private partnerships.

Resources

[1] Oregon Transportation Plan, 2006, http://www.oregon.gov/ODOT/TD/TP/ortransplanupdate.shtml

[2]ODOT's State of the System Report, 2008, http://www.oregon.gov/ODOT/TD/stateofthesystem.shtml

Data Need:

Evaluate scenarios in terms of required funding level and 8 criteria: mobility/accessibility, economic vitality, effectiveness and efficiency, equity, public support for system and financial feasibility, reliable and responsive, safety, sustainable (land consumed and land cost)

Data Sources:

Variety of sources including:

- **land use plans**
- **outputs of Oregon Statewide Model (an integrated transportation, land use, and economic model)**
- **Oregon Office of Economic Analysis**
- **Oregon Employment Department**
- **DOT transportation statistics**
- **Transit agencies**
- **Federal Aviation Administration (FAA) forecasts**

Comments: **Requires data from multiple sources**

CASE STUDY

Sustainability Diamond

What is the Sustainability Diamond?

Strategic Approach(es):

Support Comprehensive Education

Brief Description:

Assessment and visualization tool for projects and plans based on multiple sustainability criteria that could be used to compare policy and investment scenarios like those from ODOT.

The Sustainability Diamond is a tool that can be used to evaluate and compare transportation plans, policy packages, or project alternatives in terms of several sustainability parameters. As a composite index, the Sustainability Diamond is used to combine multiple performance measures into one value that reflects how well each alternative does in contributing to regional sustainability goals. The Sustainability Diamond creates an index of measures for transportation system effectiveness, environmental integrity, economic development, and social equity and quality of life. The approach (1) identifies the key decision criteria for the project, plan or policy under consideration; (2) selects appropriate performance measures for each decision criterion; (3) populates the measures with data; and then (4) normalizes and weights the measures according to their relative importance in the decision being made. The index values can be plotted and then compared for alternative plans, policies, or projects. The Sustainability Diamond can be customized to the type of plan or policy and the local context by developing goals and performance measures that reflect the sustainability issues facing a city, state, or region.

How has the Sustainability Diamond been used?

The Sustainability Diamond methodology has been used to compare three different transportation and land use scenarios for the Atlanta Metropolitan Region: Baseline 2005, Mobility 2030 (adopted regional transportation plan), and Aspirations 2030 (financially-unconstrained version of regional transportation plan). Five steps were used to develop the sustainability index and visual representation of the Sustainability Diamond.

Step 1: Identify pertinent sustainability issues or goals

Thirteen goals and objectives were developed for the Atlanta region's transportation system. In addition to transportation system effectiveness, the goals reflected the three components of sustainability:

Economic: economic efficiency, economic development, financial affordability;

Environmental: environmental integrity, natural resources, system resilience;

Socio-cultural: social equity, safety and human health, quality of life.

Step 2: Define relevant performance measures for each goal

In order to measure how well the planning scenarios met the sustainability goals, twenty-seven performance measures were identified with at least one performance measure for each goal. The list of measures was reduced to eleven because data was not readily available for each measure. Table 5-6 shows the final list of goals and corresponding performance measures, with at least one goal for each sustainability component.

Sustainability Dimension	Goals/Objectives	Performance Measures
Transportation System Effectiveness	A1. Improve Mobility	A11. Average freeway speed
	A2. Improve System Performance	A21. Vehicle-miles traveled per capita
Environmental Sustainability	B2. Minimize Air Pollution	B21. VOC emissions
		B23. NOx emissions
Economic Sustainability	C1. Maximize Economic Efficiency	C12. Total time spent in traffic
Social Sustainability	D1. Maximize Equity	D12-1. Equity of VOC exposure
		D12-2. Equity of NOx exposure
		D12-3. Equity of VOC exposure
		D12-4. Equity of NOx exposure
	D2. Improve Public Health	D21-1. Exposure to VOC emissions
		D21-2. Exposure to NOx emissions

Table 5-6. Performance measures corresponding to each goal/objective and sustainability dimension (Adapted from Jeon, et al. 2007)

Step 3: Analyze and quantify the impacts of different plans

Constructing the composite (or comprehensive) sustainability index starts with building an index for each of the four components of sustainability. Each performance measure is assigned a raw value (see Table 5-7) that is then divided by the minimum or maximum value to create a normalized value. For example, for measure A11 the maximum speed is desirable, so each raw value is divided by the highest speed (47.12) to create normalized values. Values need to be normalized so that they are unit less and can be added together. For measure B2, the minimum level of pollution is desirable. Therefore, the minimum pollution is divided by each raw value to create normalized values.

Step 4: Construct composite sustainability index using appropriate criteria and parameter weights

The next step is to assign weights to the measures that reflect the relative importance of each associated goal to regional sustainability. Assigning weights is a subjective process that can follow a variety of methods and will require the consensus of policymakers. An index is calculated as the weighted average of the performance measures:

$$Index = \sum Normalized\ Value \times Weight$$

The sustainability index is calculated in the same way as the individual indices. Each sustainability component is assigned a weighting based on priorities of the community. The comprehensive index is the weighted average the component sustainability indices (see Table 5-8 for Atlanta's component and comprehensive sustainability indices).

Step 5: Use Sustainability Diamond to illustrate trade-offs among sustainability indexes

The Sustainability Diamond can be used as a consensus-building tool for selecting among multiple plan or project alternatives. The tool illustrates the relative impacts of alternative plans on system performance, the economy, the environment and social quality of life, and helps decision makers to identify a dominant alternative. Dominant alternatives are those that are better than all others, based on all the evaluation criteria. In reality, there are usually few dominant alternatives but rather alternatives that must be considered for their tradeoffs. Thus, one plan may be particularly strong on economic impacts but weak as far as the environment is concerned, and vice versa. Where no dominant alternative is obvious, the Sustainability Diamond can help decision-makers visualize trade-offs among the four components of transport sustainability for each alternative. For example, in comparing the Baseline 2005 to Aspirations 2030, both scenarios scored similarly in economic sustainability and transportation effectiveness. While Aspirations 2030 performed much better than Baseline 2005 in terms of environmental impact, Baseline 2005 achieved a higher social sustainability index (see Figure 5-14).

The Atlanta application was intended to demonstrate how the Sustainability Diamond tool could be used to aid planning and policymaking. It has not yet been used in practice, though could easily be applied to prioritization programs like ODOT's Investment Scenarios (see Case Study 8) as a visualization tool.

Table 5-7. Raw values for selected performance measures (Adapted from Jeon et al. 2007)

Performance Measures	Unit	Baseline 2005	Mobility 2030	Aspirations 2030
A11. Average freeway speed	miles/hour	47.12	42.21	42.21
A22. Vehicle miles traveled per capita	miles/person	35.04	31.75	31.75
B21. VOC emissions	ton/day	118.33	53.38	53.38
B23. NOx emissions	ton/day	209.64	38.33	38.33
C12. Vehicle hours traveled per capita	minute/person	9.26	8.95	8.95
D12-1. Equity of VOC exposure (S)	Spatial Equity Index	19.1	23.45	23.45
D12-2. Equity of NOx exposure (S)	Spatial Equity Index	20.02	23.56	23.60
D12-3. Equity of VOC exposure (I)	Income Equity Index	10.74	55.95	427.17
D12-4. Equity of NOx exposure (I)	Income Equity Index	9.57	54.97	364.93
D21-1. Exposure to VOC emissions	Human Impact Index	1354.56	467.48	4134.47
D21-2. Exposure to NOx emissions	Human Impact Index	2269.79	318.92	2766.65

Table 5-8. Results of sustainability indexes (Adapted from Jeon, et al. 2007)

Sustainability Index	Baseline 2005	Mobility 2030	Aspirations 2030
Environmental Sustainability	0.317	1.000	1.000
Social Sustainability	0.566	0.804	0.306
Transportation Effectiveness	0.972	0.927	0.927
Economic Sustainability	0.967	1.000	1.000
Comprehensive Sustainability	0.698	0.906	0.731

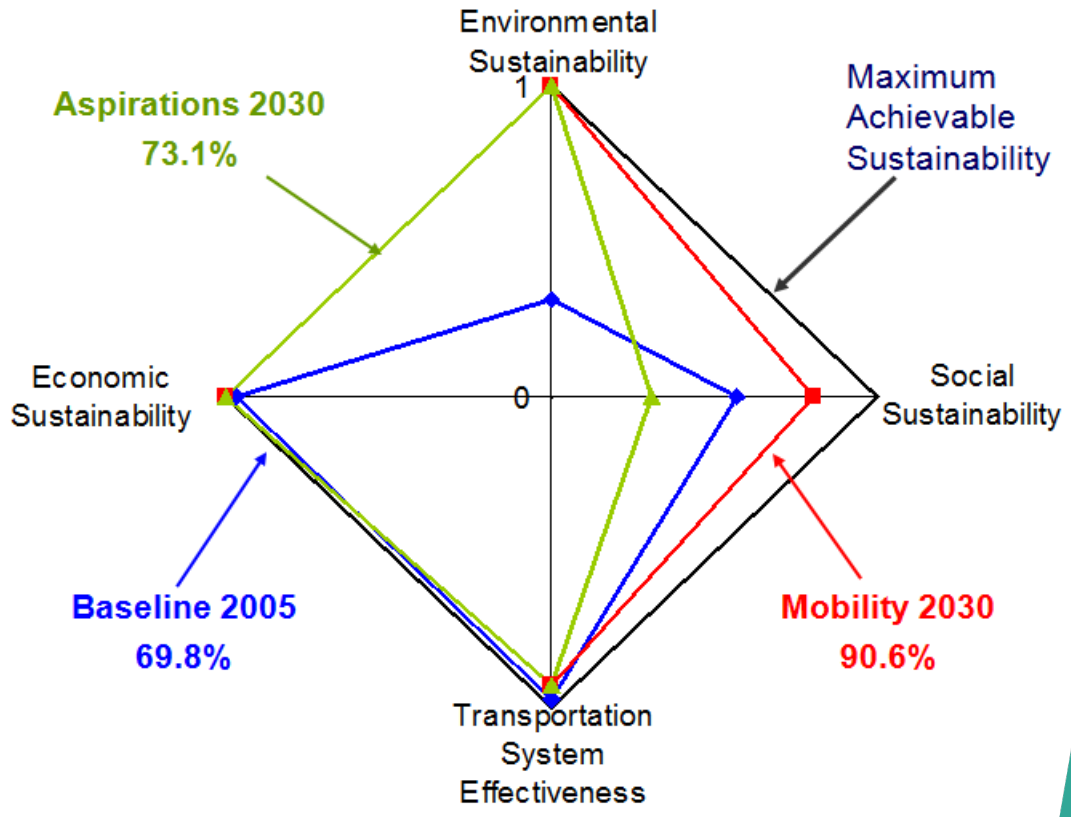

Figure 5-14. Comparison of three Atlanta regional plan alternatives using sustainability diamond. Source: Jeon, et al. 2007

Data Need:

Decision criteria and then performance measures are defined for each project, plan, or policy

Data Sources:

Data sources will vary though will likely require a mix of internally collected measures and public data sources Flexible – performance measures can be selected based on available data.

Resources

Jeon, C. M.; Amekudzi, A. A., and R. L. Guensler. (2010). Evaluating Planning Alternatives for Transportation System Sustainability: Atlanta Metropolitan Region. International Journal of Sustainable Transportation, 4: 227-247.

Comments: **Presents multiple-criteria in easy to understand form for multiple audiences. Can visualize trade-offs among criteria.**

CASE STUDY

Health Impact Assessment

What is a Health Impact Assessment?

A Health Impact Assessment (HIA) is a tool for assessing the social impacts of transportation projects and policies. HIAs are used to determine impacts of transportation on public health and wellness, including physical and mental health. HIAs can also analyze the social equity implications of projects and policies by focusing on underserved or vulnerable populations like the elderly, youth, carless or low-income households, and racial minority groups. HIA can be applied at the project or planning level, and can be used prior to or following construction/ implementation.

Strategic Approach(es):

Collaboration

Sponsoring Agency(s):

Public health departments, private foundations, local governments, federal agencies, and others

Brief Description:

Health Impact Assessment is a methodology to assess transportation in terms of impacts on public health and wellness, with a focus on underserved or vulnerable populations. It is a valuable tool for assessing the social dimensions of sustainability.

How Does a Health Impact Assessment Work?

HIA originated in the public health field in Europe as a way to measure a proposed policy, program or project's impact on community health. HIA recognizes that there are numerous health determinants and the built environment (including transportation infrastructure) has a significant influence on individual and collective health or healthy behaviors. Further, it uses a broad definition of health: "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity" [1]. In the past, HIA was used as a way to ensure that health impacts were considered in the Environmental Impact Assessment (EIA) process. Today, HIA provides a way to combine issues of environmental and social sustainability and to directly influence decision-making by bringing health to the forefront [2]. Unlike EIA, an HIA is a voluntary process in US transportation planning.

HIA generally follows six steps (see Figure 5-15).

As described by the World Health Organization (WHO), the type and complexity of the HIA depends on the scope of expected impacts and is limited by resources available (time, staff, funds). There are three main types of HIA:

1. Rapid Health Impact Appraisal: This requires the least amount of time and resources. It involves experts, decision-makers and representatives of stakeholder groups in a systematic assessment of existing knowledge on the health impacts of a proposed policy, program, or project.

2. Health Impact Analysis: This is likely the most common approach. It requires greater time and resources than a rapid HIA because it involves an in-depth assessment of potential health impacts of a decision and opportunities to adjust the policy, program, or project in support of a healthy community. This approach involves a broad

range of expertise (local government, public health, transportation engineers, community members) and the use of multiple analysis methods. In addition to utilizing existing information, health impact analysis may require production and analysis of new data (survey or interviews, GIS data, et cetera).

3. Health Impact Review: This is used when a proposed package of policies, programs and/or projects is too broad for in-depth analysis to be feasible. This approach summarizes the most important impacts on health without directly linking impacts to specific elements of the proposal or determining exact cause and effect relationships. Like the health impact analysis, this approach uses a variety of methods to assess impacts, including review of earlier published analyses of similar proposals and expert panel analysis.

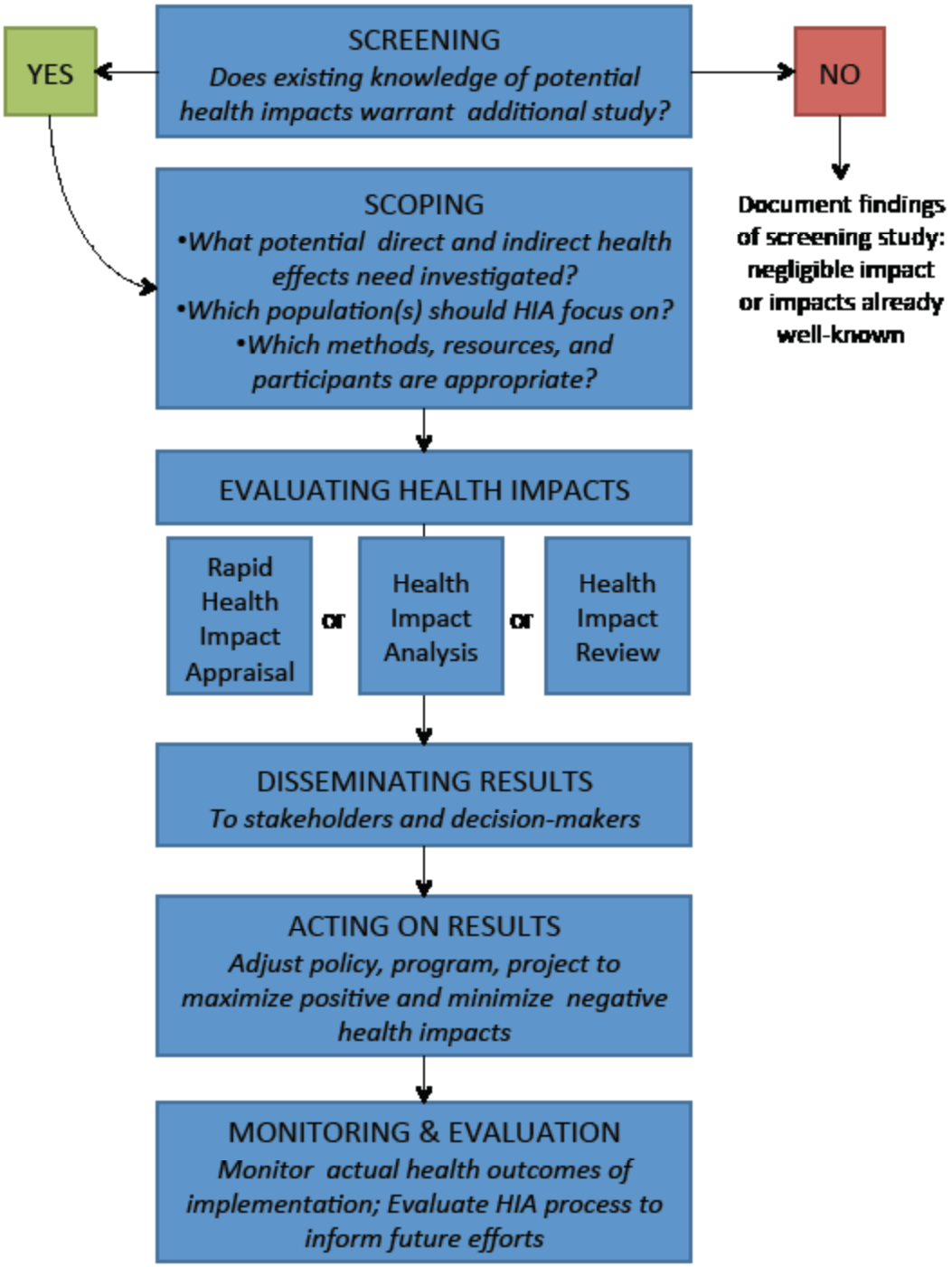

Figure 5-15. General Process of Health Impact Assessment (Adapted from WHO 1999)

The next section provides examples of different types of HIAs that have been applied in the transportation sector. Regardless of the type of HIA used, each one is "place-based" or customized to the community in question by establishing metrics for measuring and monitoring health impact. Metrics consider issues like:

- Access and connectivity to critical needs (like hospitals, healthy foods, et cetera)
- Physical health (incidence of diseases, physical activity levels)
- Social capital/social cohesion
- Environment and air quality
- Safety, both injury and crime
- Other community health priorities

At least 27 HIAs were conducted in the US from 1999-2007 and an additional ten HIAs in progress [3]. Most of the studies were sponsored by local health departments, private foundations, or federal agencies, and covered a range of polices and projects including after-school programs, power plants, land-use planning, commercial redevelopment, parks and trails, public subsidies for housing, and public transit. Nine of the HIAs investigated transportation-related health impacts. The HIAs used a variety of assessment methods such as literature review, expert panels, GIS mapping, public involvement (interviews or surveys), analysis/forecasting of travel and census data, and review of existing programs or planning documents. Most of the HIAs included recommendations for changing the proposed policy or program. However, there was little documentation of the impacts on implementation [3]. WHO provides numerous examples of HIAs conducted in transportation and other sectors, and toolkits and guidebooks on how to conduct different types of HIAs [4].

Example of Project-level HIA: Atlanta BeltLine HIA

Atlanta BeltLine Project Overview

The Atlanta BeltLine is a planned urban redevelopment project that will create a "continuous loop of urban regeneration" by combining green space, trails, transit, and new development along 22 miles of historic rail segments [5]. The BeltLine offers an opportunity to reconnect neighborhoods and provide citizens with access to key resources. The BeltLine vision is guided by a belief that a strong transportation network will promote a strong local economy. The project includes transit and roadway infrastructure improvements. Current plans propose a 22-mile loop of rail transit (either light rail or streetcar) to be funded by federal grants and local matching funds. The new transit system will connect to existing and proposed regional transit networks and link riders to major activity centers and attractions. The new transit is predicted to attract over six million new riders a year, reduce the number of rail-to-rail transfers, and improve transit travel times [6]. Roadway infrastructure projects will include streetscaping, sidewalk construction, and intersection improvements. Atlanta BeltLine will also include an extensive park and trail system. Approximately 33-miles of new multi-use trails will follow the 22-mile transit loop and extend into surrounding neighborhoods to increase access to the BeltLine. The trail-component of the BeltLine will provide connections to new and existing parks throughout the city and be designed for both recreational and commuter use [7]. Atlanta BeltLine Inc. has two transportation studies currently underway: an Environmental Impact Statement for development of transit and trails in conjunction with the Metropolitan Atlanta Rapid Transit Authority (MARTA) and design and construction of the second major trail segment, Atlanta Memorial Trail. Figure 5-16 shows a map of the Atlanta Beltline.

HIA Overall Approach

In 2007, Center for Quality Growth and Regional Development (CQGRD) at the Georgia Institute of Technology completed a Health Impact Analysis of the Atlanta BeltLine to consider the social and environmental justice impacts. The HIA evaluated the degree to which "access to parks, trails, transit, and redevelopment meet the needs of the existing and future populations, and whether improved access, and the resulting health benefits, are equitably distributed geographically and demographically" [5]. A multidisciplinary project team was assembled representing the fields of city planning (transportation, land use, economic development, environmental management, and public policy) and public health (epidemiology and environmental health). The project team recruited a six-person advisory committee to provide overall project direction, component-specific guidance, and analytical expertise. The advisory committee members had expertise in one or more of the following areas: health impact assessment, physical activity and public health, transportation planning, city and regional planning, health psychology, architecture and community design, computation and analysis, quality of life. Later in the process, the advisory committee reviewed the methodology and preliminary results and provided constructive criticism.

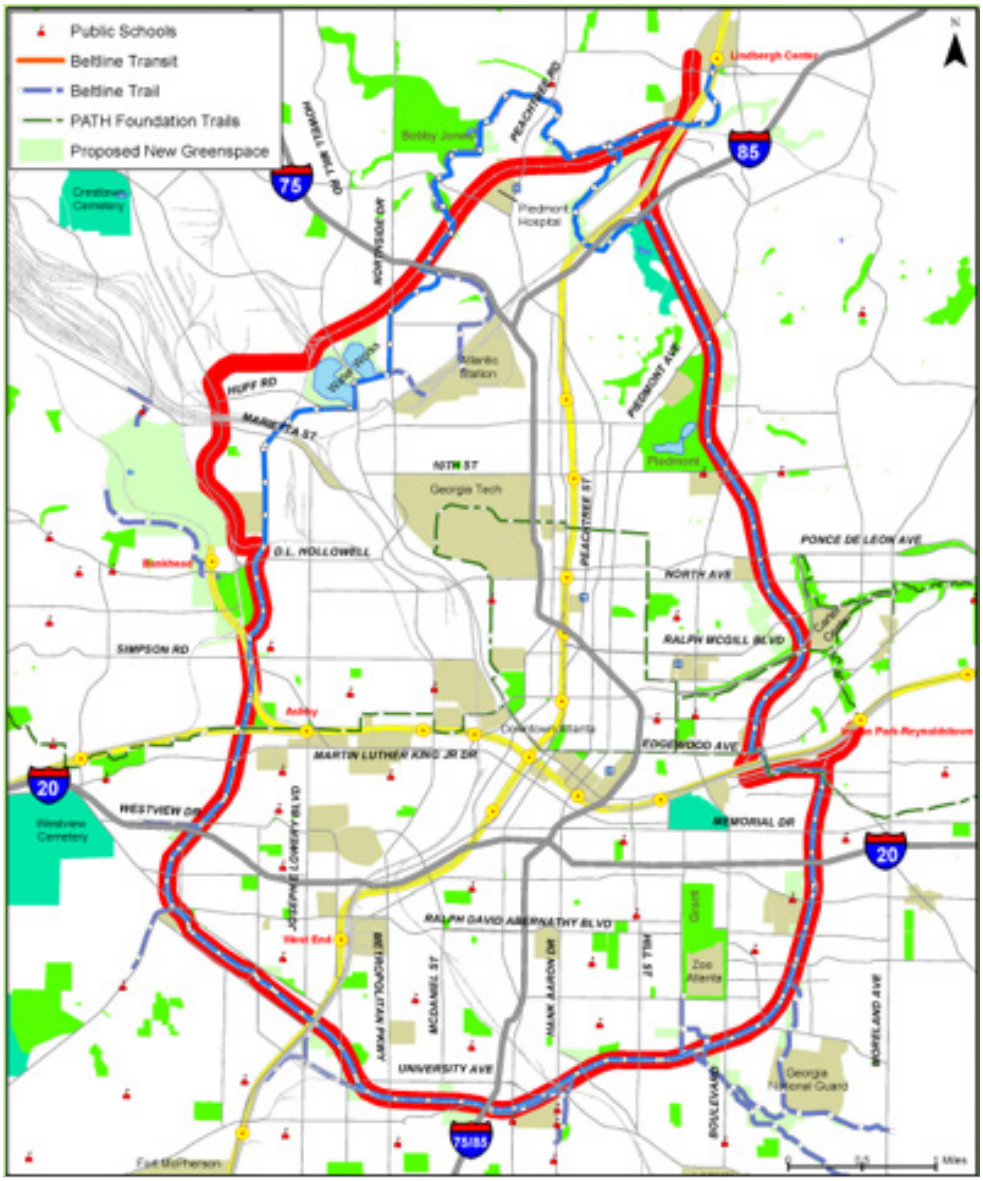

Figure 5-16. Atlanta BeltLine Concept Map (Source: The BeltLine Partnership, September 2005)

Screening Process

The screening process was conducted during development of the grant proposal. Through a series of meetings, the project team determined that Atlanta BeltLine could impact community health through noise, injury, physical activity, air quality, social capital, crime, accessibility, and gentrification. The team also determined that additional study was needed to assess the direction, magnitude, and distribution of health impacts. Further, the team recognized that a more thorough investigation of the health impacts could lead to a better BeltLine project.

Scoping Phase

The scoping phase involved identifying the parameters of the assessment, the affected and most vulnerable populations, and potential benefits and negative consequences. The project team defined the study area by a 0.5-mile buffer of the BeltLine, based on the distance people are typically willing to walk to transit, parks, and other destinations. The study area was also divided into five segments that corresponded to the City of Atlanta's designated BeltLine Planning Areas. The segments were used later to compare impacts along different parts of the BeltLine. By closely examining the affected population in the study area and previous research in this area, the project team defined "vulnerable populations" as children, older adults, renters, carless, and low economic status. The project team used several approaches to identify potential key health impacts, which were those issues that concerned the public most, may have the greatest impact in terms of severity or number of people affected, or may affect the most vulnerable populations. The team used content analysis of recent local newspaper coverage of the BeltLine, developed a logic framework to draw connections between elements of the project and potential impacts (see Figure 5-17), and engaged in extensive public involvement and education. CQGRD completed a survey of almost 500 people living, working, or going to school near the BeltLine to gauge opinions of current health conditions and perception of BeltLine impacts. During the scoping phase of the HIA, the advisory committee helped refine the scope and recommended data sources and participation strategies. At the end of the scoping phase, the project team identified five critical issues that would be assessed in the next phase: access and social equity, physical activity, safety, social capital, and environment (air quality, noise, and water management).

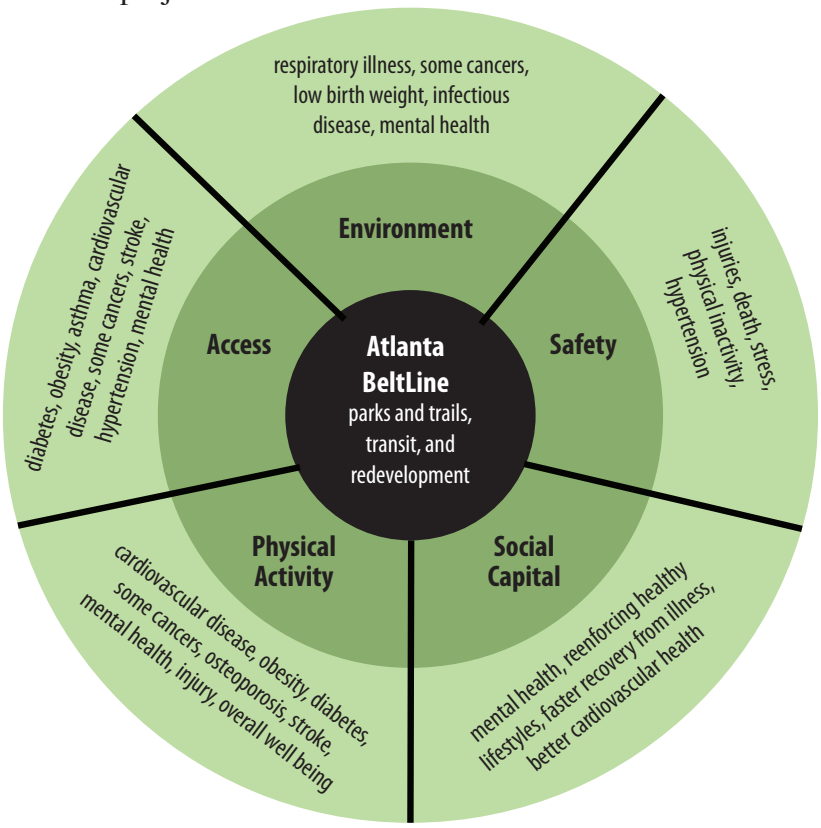

Figure 5-17. Logic framework of potential health imapcts (CQGRD 2007)

Evaluation Phase

The evaluation phase involved profiling the affected communities, identifying and

characterizing potential health impacts, and GIS analysis to determine distribution of health impacts. Evaluation included both quantitative (population and employment projections, GIS analysis) and qualitative methods (literature review, expert opinion) and required numerous data sources (both publically available and newly generated) including:

- GIS files of BeltLine alignment, locations of existing and proposed parks and trails, locations of grocery stores;
- US Census data (Year 2000);
- Atlanta Regional Commission population statistics and projections and travel demand model;
- City of Atlanta crime rates;
- Survey responses; and
- Previously published studies on critical health issues.

Results

The results were reported along with recommendations for minimizing negative impacts and maximizing benefits, particularly in planning areas with large vulnerable populations. Overall, benefits were found to be distributed along the entire BeltLine. The study did observe some disparities based on race or income, and suggested that refining the BeltLine plans to focus development in vulnerable areas could resolve those issues. Table 5-9 shows examples of measures and key findings related to each of the critical health issues. The full Atlanta BeltLine HIA report containing more detail, describing methodology and recommendations, is available at www.cqgrd.gatech.edu/projects/beltline_hia/index.php.

Table 5-9. Summary of Key Issues, Measures, and Findings from Atlanta BeltLine HIA

Issue	Examples of Measures	Examples of Findings
Access and Social Equity	• Number of people (before and after implementation) with access to (1) parks and trails, (2) transit, (3) housing, (4) healthy food • Composition of population with access (before and after implementation) NOTE: "Access" defined as living within 0.5 miles of amenity	• New access to parks for approximately 11,000 people (based on 2000 population), or about five percent of the study area population • 41 percent of the study area population would have access to the trail system • Improved access to transit for 36 percent of study area population provides positive health benefits by enabling higher labor participation rate, offering an opportunity for physical activity (to and from transit), and providing better access to essential services, such as healthcare • Grocery stores located in neighborhoods that are majority white and of higher socioeconomic status than study area population
Physical Activity	• Mortality rates for chronic diseases linked to lack of physical activity • Access to parks, trails, and transit	• Both parks and trails offer opportunities for physical activity, which is imperative for health • BeltLine will increase opportunities for physical activity in planning areas with highest mortality rates
Safety	• Crime rates (local, national, transit-related) • Potential for injury	• Survey responses: low crime rates have positive effect on health; BeltLine will not lower crime rates but will still have positive effect on health • Survey responses: Both injury and crime were concerns, but not top health concerns for most people • Increased bike and pedestrian activity may reduce risk of bike and pedestrian crashes
Social Capital	Degree to which people feel that they live in and belong to a socially cohesive group, and range of activities and resources that emerge as a consequence of those ties	• 5% of survey respondents felt BeltLine would improve their sense of community • Potential to improve social capital by preserving existing neighborhoods, creating places for formal and informal social interactions, and embracing an inclusive public participation process
Environment	• Change in traffic volumes and related air quality issues • Stormwater run-off and management (function of design and amount of impervious surface) • Levels of noise and vibration • Location of brownfields	• Transportation improvements would only achieve a four percent reduction in traffic volume growth (as projected by Atlanta Regional Commission); BeltLine would have a minimal positive impact on air quality • Could not quantify stormwater impacts without detailed development plans • Brownfields more likely to be located near low-income and non-white populations

Examples of Other Completed HIAs in Transportation

Planning Analysis: Decatur Community Transportation Plan Rapid HIA

When Decatur, Georgia commenced a comprehensive transportation planning effort in 2006, the community made a commitment to active living through active travel. As part of the planning process, CQGRD conducted a Rapid HIA to identify health impacts related to safety, social connections and physical activity as affected by transportation and land use decisions. The Rapid HIA began with a community workshop investigating the concerns of Decatur residents, businesses, and institutions. CQGRD then used findings from more than 100 research articles and books and insights from local, regional and national experts

in planning and health to identify potential health impacts and recommend strategies to increase the number of positive health outcomes and remove or mitigate negative health outcomes. Following completion of the Community Transportation Plan in Fall 2007, Decatur created a new Active Living Division within the Department of Community and Economic Development that combines traditional recreation programs with quality of life programs like environmental sustainability, alternative transportation planning and efforts to encourage an active living lifestyle in the community [5].

See www.cqgrd.gatech.edu/projects/decatur_transportation_plan/pdfs/decatur_rapid_hia_final_report.pdf for the full Decatur HIA report.

Multiple Levels: New Zealand Transport Agency's Applications to Land Transport

New Zealand Transport Agency conducted a review of HIA that included three case studies of completed HIAs. The case studies demonstrated applications of both strategic and project level HIA. The case studies assessed the HIA process – why, when, and how it was conducted and its value to planners and other stakeholders. Also, the case studies cover what worked well and what did not. They helped NZTA conclude that HIA needs to be integrated into their transportation planning process in order to better protect public health [8]. The three case studies were:

- Greater Wellington Regional Land Transport Strategy HIA: The study followed the general-process described in Figure 14 and included stakeholder workshops during the scoping and appraisal/evaluation stages. The assessment focused on the draft transport strategy and was guided by the principles of democracy, equity, sustainable development, and ethical use of evidence. The regional planning council openly responded to the HIA recommendations, and either accepted or rejected each before finalizing the transport strategy.
- North Nelson to Brightwater Corridor Study HIA: A "desk-top" HIA (a form of rapid HIA) informed the corridor study which was needed to accommodate projected growth and relieve congestion. It is called "desk-top" because the process was carried out in-house by public health officials, rather than seeking direct input from experts and the public. The HIA staff was careful to consider issues from the public's perspective and paid particular attention to vulnerable communities. The primary recommendation was to conduct a full HIA for project alternatives.
- Wairau–Taharoto Corridor Upgrade HIA: The project-level HIA followed the steps of screening, scoping, evaluation, and reporting with input from a multi-disciplinary expert panel at each stage. There was limited public involvement because of time and budget constraints. The HIA took place late in the planning process and lacked buy-in from the project manager, and so the recommendations had little impact on final design.

The World Health Organization provides numerous other examples of HIAs conduct for transportation projects, plans, and programs at http://www.who.int/hia/examples/trspt_comms/en/index.html.

Assessing the Outcomes of HIAs

To be complete, HIAs must be assessed for their outcomes or impacts. Questions that must be asked include the following:

- Are there measurable outcomes?
- Has it influenced project selection? Led to changes in project design?
- Has it led to new programs?
- How has it influenced policy?

The effectiveness of HIAs is often a function of commitment, in terms of time and monetary resources and buy-in from transportation officials, the public, and politicians. HIA could be a valuable tool for assessing social impacts of transportation projects, but it has to be made a priority.

Data Need:

BeltLine metrics related to:

- **Access and Social Equity (parks, trails, transit, housing, food)**
- **Physical Activity (parks, trails, transit, urban form)**
- **Safety (injury and crime)**
- **Social capital**
- **Environment (air quality, water quality, noise and vibrations, brownfields)**

LCI metrics related to:

- **Access to Transportation Options**
- **Access to Parks & Greenspace**
- **Access to Healthy Housing**

Data Sources:

- **Georgia Department of Human Resources, Division of Public Health**
- **US Census 2000 (census track)**
- **BeltLine studies (private and non-profit sources)**
- **Atlanta Regional Commission population estimates**
- **US DOT traffic and accident data**
- **Atlanta Development Authority housing data**

Comments: **Primarily GIS-based analysis that may require converting existing data into GIS-compatible formats**

Resources

[1] World Health Organization (WHO). (1999). Health Impact Assessment : main concepts and suggested approach. Gothenburg consensus paper, Brussels, Belgium.

[2] Allen, M. (2009). "2009 Evaluating the Livable Centers Initiative : The Case for Using Health Impact Assessment." 1-71. Master's Option Paper, Georgia Institute of Technology City and Regional Planning Program. Unpublished.

[3] Dannenberg, A. L., Bhatia, R., Cole, B. L., Heaton, S. K., Feldman, J. D., and Rutt, C. D. (2008). "Use of health impact assessment in the U.S.: 27 case studies, 1999-2007." American journal of preventive medicine, 34(3), 241-56.

[4] WHO. (2010). Health Impact Assessment. <http://www.who.int/hia/en/>

[5] Center for Quality Growth and Regional Development (CQGRD). (2007). Atlanta BeltLine Health Impact Assessment and Decatur Community Transportation Plan. Available at http://www.cqgrd.gatech.edu/publications/studies.php.

[6] MARTA. (2007). Detailed Technical Screening and Selection of Locally Preferred Alternative (LPA). Available at http://itsmarta.com/newsroom/beltline.html.

[7] Atlanta BeltLine Inc (ABI). (2007). "BeltLine Basics." BeltLine: Atlanta Connected. Accessed 1 April 2008 at http://www.beltline.org/BeltLineBasics/BeltLineBasicsOverview/tabid/1691/Default.aspx.

[8] Ball, J., Ward, M., Thornley, L, and Quigley, R. (2009). Applying health impact assessment to land transport planning. NZ Transport Agency Research Report 375. Available at http://www.nzta.govt.nz/resources/research/reports/375/docs/375.pdf.

CASE STUDY

NYSDOT

Climate Change and Energy Efficiency Team

How did NYSDOT get involved with climate change?

New York State (NYS) recognized that climate change could have serious impacts on its infrastructure. NYSDEC reports that climate change effects were already being seen in NYS in 2010:

- Warmer temperatures, especially in winter;
- Longer growing seasons and shorter periods of winter snow cover;
- Higher sea levels;
- An increase in high-precipitation weather events;
- Climate-linked stresses on traditional species. [1]

Most of these trends could have a significant impact on transportation infrastructure. As a result, NYS government has been proactive in addressing greenhouse gas emissions from transportation and the potential implications of climate change. The 2002 NYS Energy Plan touches on transportation, environment, energy, and economic development issues. Thirty out of 65 recommendations were directly or indirectly related to transportation, and involved quantifying and mitigating the energy use and air pollution expected from transportation plans and programs [2]. In April 2008, Governor David Paterson issued Executive Orders No. 2 and 4. No. 2 established an Energy Planning Board to create and implement a State Energy Plan and No. 4 established green procurement rules and agency sustainability programs. A new statewide energy plan was released in 2009 and contains energy demand and price forecasts, assessment of energy resources, and strategies for transportation and other sectors. In August 2009, Governor Paterson signed Executive Order No. 24, which set a goal to reduce greenhouse gas emissions in the state by 80 percent below the 1990 levels by the year 2050. To achieve the goal, the Executive Order created a Climate Action Council with a directive to prepare a Climate Action Plan by December 2010 [4]. The Climate Action Plan will assess how all economic sectors can reduce greenhouse gas emissions, adapt to climate change, and support a clean energy economy [4].

In response to the state's energy and climate change directives,

Strategic Approach(es):

Laws & Directives

Collaboration

Partners:

NYS Energy Research and Development Authority (NYSERDA), Metropolitan Planning Organizations (MPOs), NYS Climate Action Council, NYS Energy Planning Board, NYS Department of Environmental Conservation (NYSDEC)

Brief Description:

NYSDOT's Climate Change and Energy Efficiency Team coordinates internal and external initiatives including the following: reporting greenhouse gas emissions for transportation improvement programs (TIPs) and long-range plans; analyzing emissions at the project level to compare alternatives; identifying ways to reduce transportation energy costs for the public; promoting energy efficient programs and projects; and reducing NYSDOT's carbon footprint.

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NYSDOT established a Climate Change & Energy Efficiency team. The team's mission is to assist the DOT in its efforts to have the DOT and the State's transportation sector reduce their greenhouse gas emissions and reliance on petroleum. Staff from around the agency participate in a series of work groups to address various aspects of the effort. The initiative is coordinated by the Office of the Environment and the Policy and Planning Division.

How is NYSDOT tackling Climate Change?

To reduce greenhouse gas emissions and energy use from the transportation sector, NYSDOT has strategies on four fronts (or the 4 legged stool in Figure 5-18):

1. Vehicle technology,
2. Fuels, and
3. Vehicle miles traveled (VMT)/demand management.
4. Vehicle/system operations

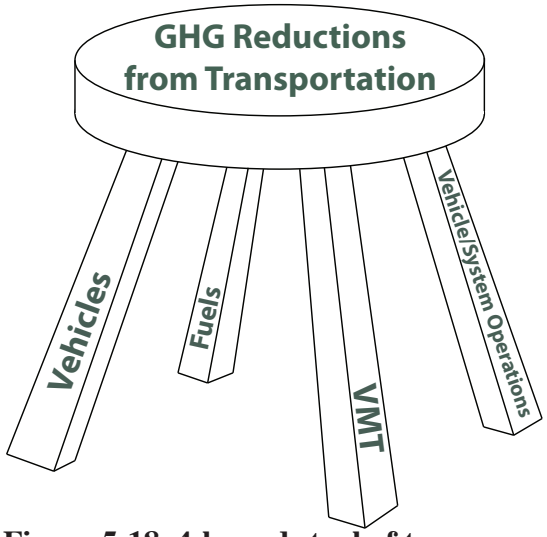

Figure 5-18. 4-legged stool of transportation GHG reduction strategies.
Source: http://www.fhwa.dot.gove/hep/climate/gccalbany.htm

NYSDOT's efforts are being coordinated by the Climate Change and Energy Efficiency Team (CC/EE Team), which consists of approximately 70 members representing departments from throughout the agency. The team is supported at the Executive level and is charged with institutionalizing climate change/energy efficiency into everything DOT does. Activities range from shaping major policy and project directions to influencing actions of individual DOT employees. The CC/EE Team is divided into 6 workgroups that work with each other and with other state agencies. Table 5-10 shows a breakdown of the workgroup responsibilities.

Table 5-10. Workgroups and responsibilities of Climate Change and Energy Efficiency Team

Workgroup	Primary Responsibilities
NYS transportation sector	Work with MPOs, other transportation agencies and the general public to incorporate CC/EE considerations in statewide and metropolitan plan and program development.
NYSDOT carbon footprint	Report emissions inventory of NYSDOT's vehicles, buildings, planning practices, design procedures, construction specifications, and maintenance practices.
Fuel availability and cost forecasts	Work with NYS Energy Research and Development Authority (NYSERDA) to develop short-term and long-term energy forecasts, examine fuel cost effects on funding and basic transportation needs, and identify ways to adapt to changes in fuel prices or supply.
Adaptation	Investigate how to adapt design, construction and maintenance practices/specifications to statewide effects of climate change and identify funding for adaptation measures.
Outreach and Education	Develop an outreach plan and promote CC/EE to external stakeholders. Solicit ideas from NYSDOT employees and establish a web board for sharing informationo with NYSDOT employees.
Outreach and Education	Identify available federal, state, and local funding resources for climate change and energy efficiency programs. Develop a new funding source for local projects that promote CC/EE.

Transportation Strategies from NYS Energy Plan

Vehicle technology

- **Electrification of transportation sector**
- **Tightening Corporate Average Fuel Economy (CAFE) standards**
- **Transportation energy research & development**

Transportation fuel

- **Expansion of use of alternative fuels**
- **Exploration of renewable resources**
- **Testing out of new fuels on public sector fleets**

Energy efficient transportation system activity

- **Targeting investments at bottlenecks and locations with greatest potential to reduce congestion**
- **Updating highway construction and maintenance practices to reflect most recent energy efficient methods**
- **Reducing VMT statewide by 10% from projected levels from 2010-2020**
- **Promoting transit oriented development & Smart Growth initiatives**

NYSDOT's climate change initiatives address both planning and project development. At the planning level, the DOT compares the direct and indirect energy requirements of the no action scenario with the TIP or LRP Scenario. This provides a way to weigh the benefits of new capacity and operational projects against the costs of potentially higher energy use. Project-level analysis is conducted for major projects, and includes a comparison among different alternatives including the no-build scenario. Project-level calculations cover construction, operational, and maintenance aspects of the projects. NYSDOT has found that differences among the alternatives range from 1700 to 15000 tons of carbon per year. To put that value in perspective, an average coal-burning power plant emits 1 million tons of carbon per year.

Another notable CC/EE initiative is the Clean Air NY campaign (www.cleanairny.com). It is a year-round program that seeks to improve air quality in the New York metropolitan area by educating residents and organizations about simple ways they can change their travel behavior. Website provides information for individuals like simple, everyday travel changes that all New Yorkers can make to improve air quality. It also offers information for organizations on helping employees make smarter choices. Everyone can benefit from the commuting information, such as locating a carpool or vanpool, and Air Quality Action Day Bulletins that provide information on poor air quality days and what people can do to improve the air on those days.

In addition to the DOT's activities, members of the CC/EE Team are contributing to statewide efforts. First, the acting DOT commissioner serves on the Statewide Energy Planning Board, helping to set the strategic direction for the transportation sector (Box 3 shows priorities from 2010-2020). NYSDOT representatives also serve on the NYS Climate Action Council's Transportation and Land Use (TLU) Technical Work Group and the Adaptation Technical Work Group. These representatives are helping to develop the NYS Climate Action Plan and each work group is contributing data to the state greenhouse gas inventory [9]. Additionally, NYSDOT is serving on the state's Sea Level Rise Task Force, which is identifying infrastructure (including transportation) that is vulnerable to sea level rise. The final report, scheduled for a January 2011 release, will make recommendations for adapting infrastructure, establishing protective standards and enforcement for natural systems, and making changes to state and local statutes to respond to climate change.

NYSDOT "Top 11" List of Actions

- **Mass transit**
- **Emissions reporting**
- **Traffic signals**
- **Freight management**
- **Managed lanes**
- **Smart growth/land use**
- **Idle reduction**
- **Commuter Choice**
- **Air quality education**
- **Alternative fuels**
- **Research**

What has the Climate Change & Energy Efficiency Team accomplished?

Data Need:

Quantify and mitigate the energy use and air pollution expected from transportation plans and programs with strategies on four fronts: (1) vehicle technology; (2) fuels; (3) vehicle miles traveled (VMT)/demand management; (4) vehicles/system operations

Data Sources:

Internal research

- **carbon highway footprint modeling using the capabilities of TRANSIMS and real-time commercial vehicle data acquisition**
- **car share research**
- **recycled material research**

External partners/sources

- **NYS Energy Research and Development Authority (NYSERDA)**
- **CO2 Allowance Auctions**
- **NYS Climate Action Council**
- **NYS Energy Planning Board**
- **NYS Department of Environmental Conservation (NYSDEC)**
- **Green technology manufacturers**

Comments: **Data is specific to NYS, so may be difficult to replicate the footprinting method**

New York State has demonstrated that CC/EE initiatives can have a significant impact on air quality and energy use. Initial statewide results of State Energy Plan showed a direct energy reduction of 43.5x109 BTUs per day and a carbon reduction of 6,381 tons per day, which equates to about 4% of New York City's daily carbon emissions in 2005 [10]. NYSDOT contributed to the reductions with a package of policies and programs that it introduced from 2008 to 2010. One of the most recognizable CC/EE initiatives is the GreenLITES project rating system, which is highlighted in another case study (see pages 96-100). Other practices can be found at the individual employee level all the way to more strategic directions for the DOT. Table 5-11 shows examples of common practices to address climate change.

Table 5-11. Summary of NYSDOT practices to address climate change

Implementation Level	Initiatives
Individual	• Pilot compressed work week for NYSDOT employees (as of October 2009, 12% of employees participated) • Shut down computers at night
Project	• B5 biodiesel in NYSDOT diesel fleet • LED traffic lights • Selective building retrofits/upgrades • Experiment with Warm Mix Asphalt and recycled materials • TOD training in Tappan Zee/Hudson Valley corridor
Strategic	• Soliciting New York State version of Gulf Coast study • Developed methodological guidance for MPOs to assess energy use and GHG emissions from TIPS and LRTPs • Consider emissions and energy use during project alternative selection for major highway projects • Carbon Highway Footprinting Research • Joint research co-funded with NYSERDA: 2 rounds of RFPs, $3.2 million, 20 projects selected • Involvement with Regional Greenhouse Gas Initiative (RGGI) Carbon Dioxide Budget Trading Program • Launched Smart Growth website (www.nysdot.gov/smartplanning)

Current and future activities will be documented on the NYSDOT CC/EE website. The true impact of NYSDOT's CC/EE initiatives will be seen over time with the release of future greenhouse gas emission inventories.

Resources

[1] http://www.dec.ny.gov/energy/44992.html

[2] http://itre.ncsu.edu/CTE/Techtransfer/Teleconferences/docs/TC43-Zamurs-Slides-Handout.pdf

[3] NYS climate and energy planning, http://www.dec.ny.gov/energy/44992.html

[4] http://www.state.ny.us/governor/press/press_0806091.html

[5] http://www.nyclimatechange.us/index.cfm

[6] http://www.wtsinternational.org/uploadedFiles/Chapters_-_Community/CT_Valley/Document_Library/2009%20TMS%202b_Transportation%20and%20Climate%20Change_John%20Zamurs.pdf

[7] https://www.nysdot.gov/divisions/engineering/technical-services/trans-r-and-d-repository/NYSDOT%2520Energy%2520and%2520Climate%2520Change%2520Report.pdf

[8] "New York - Integration into Transportation Decision Making: Case Studies: State DOT Activities", DOT Transportation and Climate Change Clearinghouse, http://climate.dot.gov/state-local/integration/case-studies/state-dot-activities.html#NY

[9] State Greenhouse Gas Inventory, http://www.nyclimatechange.us/InventoryForecast.cfm

[10] Inventory of New York City Greenhouse Gas Emissions, April 2007, http://www.nyc.gov/html/om/pdf/ccp_report041007.pdf

CASE STUDY

Caltrans Climate Action Program

Why is Caltrans addressing Climate Change?

Strategic Approach(es):

Laws & Directives
Collaboration

Brief Description:

Caltrans' Climate Action Program was developed as an interdisciplinary approach to address both emission reduction and adaptation measures to prepare for climate change impacts. Caltrans will also help regional agencies incorporate GHG reduction strategies into Regional Blueprint plans (see Regional Blueprints Case Study).

A 1.4 meter sea-level rise over the next century will "put 480,000 people at risk of [what is considered today] a 100 year flood" which would become a common event and cost $100 billion to replace flooded property assuming current levels of development.
~ California Sea Level Rise Report

Climate change impacts like higher temperatures, sea level rise, and more extreme weather events could have a significant impact on transportation infrastructure. And the transportation sector itself is a major contributor to climate change through GHG emissions. In California, transportation represents 40 percent of all anthropogenic GHG production. Annual net GHG from transportation are roughly equal to the product of the number of vehicles, average number of miles traveled by each vehicle, and average net emissions of GHG per vehicle mile traveled. In addition to the emissions, California's unsustainable transportation leads to major economic costs. In 2005, California drivers used an estimated 18.1 billion gallons of motor fuel at an estimated cost of $44 billion and traveled 330 billion miles, representing a 15 percent increase from 1990. While net emissions per VMT may decrease over time, 2005 trends projected significant increases in VMT per vehicle and the number of vehicles on the road [3]. If those trends continued, California would increase its gasoline use and associated GHG emissions 30 percent by 2025. Overall, California represents 6.2 percent of the US's GHG emissions [from California's Climate Change Portal].

In response to the serious economic and environmental threats posed by climate change, the California Governor's Office and State Legislature have issued a series of directives for dealing with greenhouse gas emissions and climate change impacts. Governor's Executive Order S-3-05 established GHG emissions reduction targets and created the State's Climate Action Team to lead efforts. In 2006, AB32: Global Warming Solutions Act reinforced the reduction targets, including a reduction to 1990 levels by 2020, and created a comprehensive, multi-year program to accomplish that. In 2009, SB 375 required regional governments to include sustainability and GHG reduction strategies and targets in regional planning. In addition to the state lead, Caltrans Director Will Kempton issued his Policy on Energy Efficiency, Conservation and Climate Change in 2007 to outline the Department's policy and program roles and responsibilities. The Director's policy strived to integrate climate change considerations into normal business operations in order to prove that transportation efficiency and greening measures can have multiple benefits. In addition to easing congestion to lower GHG emissions, he wanted to show

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POTENTIAL INFRASTRUCTURE IMPACTS DUE TO WARMING

- **Higher average temperatures**
- **affect energy production, transmission and demand;**
- **increase cooling demands,**
- **decrease water availability for hydropower generation**
- **increase risk of brown-outs and black-outs**
- **impact transmission efficiencies**
- **Temperature extremes**
- **increase road and railroad track buckling**
- **decrease in transportation safety and higher costs**

POTENTIAL INFRASTRUCTURE IMPACTS DUE TO SEA-LEVEL RISE AND EXTREME EVENTS

- **Seaside Airports - Vulnerable to storm-related inundation**
- **Seaports and Docks – Inundation and flooding impedes business**
- **Roads and Railroads - Risk of storms and coastal flooding**
- **Sea-Level Rise and Coastal Surges - Requires increased fortifications or relo cation at high economic costs**
- **Sea Water - Floods can damage coastal water sanitation systems, requiring costly upgrades**
- **Sea-Level Rise and River Flooding – Will impact bay-delta levee system**

[from California Climate Adaptation Strategy]

that climate change efforts could lead to economic gains and opportunities to create new markets like in the energy sector.

In order to do its part to reduce emissions, Caltrans works closely with the California Air Resources Board and serves on the Governor's Climate Action Team. A key outcome of that work was the 2006 Climate Action Program Report. The Department also collaborates on a variety of initiatives with local and regional agencies, academic and research institutions, NGOs and other environmental and energy stakeholders.

What is the Climate Action Program?

The Climate Action Program (CAP) at Caltrans is an interdisciplinary effort to make climate change a part of day-to-day activities and to promote, facilitate, and coordinate implementation of strategies with partner agencies. The CAP focuses on climate change mitigation through greenhouse gas (GHG) emission reduction and advances adaptation measures to protect the transportation system from climate change impacts. The program serves as a resource for technical assistance, training, information exchange, and partnership-building opportunities. The overall objectives of the CAP are to:

1. develop transportation strategies, plans, and projects to contribute to the State's GHG emission reduction plan,
2. provide guidelines, procedures, performance measures, and a quantifiable set of reporting protocols to monitor GHG footprints,
3. consider potential impact of climate variability on transportation system and develop risk assessment for long lasting transportation investments, and
4. advance applied research to support climate change knowledge base in transportation. [1]

Caltrans is pursuing these objectives in two ways: building a more efficient transportation system and providing cleaner, more energy efficient transportation operations. The first approach focuses on reducing, managing, and eliminating trips that cause congestion and emissions by investing in ITS, demand management, value pricing, smart land use, and market based strategies. Example initiatives include Regional Blueprint Planning, local development/intergovernmental review, transportation planning grants, and congestion relief projects on high travel corridors. The second approach will incorporate energy

efficiency and GHG reduction measures into the planning, design, construction, operations and maintenance of transportation facilities, fleets, and buildings. With the two-fold approach, Caltrans estimated that it could reduce 18.67 MMT of CO2 emissions by 2010, saving 1 billion gallons of gasoline and retaining $2.45 billion in the State's economy [6].

Caltrans Office of Policy Analysis and Research (OPAR) manages the Climate Action Program and is specifically responsible for:

- Coordinating and monitoring climate activities and strategies across departmental pro grams and with other state, regional, local agencies and boards;
- Serving as a primary point of contact for climate change and transportation energy;
- Mainstreaming greenhouse gas emissions and energy efficiency measures into plan ning and project development. [6]

The CAP also receives oversight from the Caltrans Director who provides overall direction for the program. A Management Steering Committee consisting of Directors, Division Chiefs, and project managers from several groups oversee the work plan and delegate tasks to the Technical Working Group that consists of representatives from Resource Conservation, Environmental Analysis, Traffic Operations, Maintenance, Equipment, Transportation Planning, Research and Innovation, and Engineering Services [3].

What has the Climate Action Program accomplished?

The 2007 Climate Action Charter set forth the purpose of the CAP and a list of short-term products. In fulfillment of a work product, Caltrans was one of the first state agencies to successfully certify its GHG inventory with the California Climate Action Registry, a private nonprofit organization that promotes early actions to reduce emissions and develops credible, accurate, and consistent GHG reporting standards. Caltrans also helped produce the 2009 California Climate Adaptation Strategy which suggests the following actions for transportation:

- Develop a detailed climate vulnerability assessment and adaptation plan for California's transportation infrastructure.
- Incorporate climate change vulnerability assessment planning tools, policies, and strategies into existing transportation and investment decisions.
- Develop transportation design and engineering standards to minimize climate change risks to vulnerable transportation infrastructure.
- Incorporate climate change impact considerations into disaster preparedness planning for all transportation modes.

Caltrans future work will address these strategies and provide guidance for planning activities at all levels: strategic, system planning, regional planning, project development and programming.

In November 2008, Caltrans released an addendum to the 2007 Regional Transportation Plan Guidelines to account for climate change and greenhouse gas emissions during that process. The Fleet Greening Program began as a five-year plan in August 2000 and has been continued to promote an efficient fleet mix and use of efficient, low emission vehicles. Specific initiatives in the Fleet Greening Program include regulation compliance, state purchasing policies, and demonstrations of hybrid passenger vehicles, solar-powered

equipment, propane-fueled vehicles, low dust street sweepers, diesel particulate filters on heavy-duty, diesel-powered vehicles, two hydrogen demonstration vehicles, and E-85 fuel ethanol demonstration [8].

Each year, Caltrans gathers data on a monthly basis on greenhouse gas emissions in order to compile GHG inventories (assuming no budget constraints). Much of this data is collected by examining purchase records of various gasses, such as acetylene, and by observing bulk re-fueling totals, which are fueling stations for Caltrans vehicles only. These stations track gallons by fuel type, and also gather data on how much power is being used by the vehicle. The inventory is sent to the California Climate Action Registry and verified by a third party before it is published. Other private institutions also complete their own GHG inventories on differing intervals of time, whether it be every year or every 4-5 years. During periods when Caltrans is financially constrained and unable to report a full inventory to the registry, the agency continues to collect data internally and monitor changes in energy usage and sources. By publishing the GHG inventories, Caltrans is able to communicate successful outcomes, like the use of alternative fuels (biodiesel and ethanol) and the reduction of emissions by changing power sources (conversion of street lights to LED bulbs). Caltrans can then use the success stories (backed by real data) to promote expansion of emissions-reduction practices and to explore new practices. Despite their success, Caltrans recognizes that there are limitations to the internal tracking systems, but this must be solved by the managerial divisions within Caltrans. With better internal tracking systems, Caltrans would be able to complete inventories more easily and with lower costs.

Another notable outcome of the CAP is a Sea-Level Rise Study for California's coast that was released in 2009. Caltrans partnered with the Pacific Institute and several state and national agencies to investigate past trends in sea level rise and project future impacts. The study provides a detailed analysis of the population, infrastructure (including transportation), and property at risk from projected sea level rise over the next century. Risks are primarily related to coastal flooding and infrastructure erosion. The report provides estimates for costs of replacing at-risk property and a comprehensive list of recommended strategies for adapting to sea-level rise, including structural and non-structural policies [5].

Currently, Caltrans is working with the NASA Academy of Sciences to put together a more extensive sea-level rise study. After receiving this data, which is planned to be finalized within 12-18 months, they will update the short term products time table and move forward with new initiatives. One of these new initiatives is something called a "hotspot map". Since there is no coordinated master plan for transportation systems directly affected by the anticipated sea level rise, Caltrans is working with the University of California-Davis to compile this data and create reference maps to help with climate-sensitive regional planning. The hot-spot maps will identify critical transportation infrastructure located throughout the entire state that will need to be adapted or reconstructed in preparation for sea level rise. By using resources like the hotspot map, quantifiable data from researching with other state institutions, and regional/master treatment plans,

Data Need:

Two methods:
-building a more efficient transportation system: implementing smart growth/land use
-providing cleaner, more energy efficient transportation: non-vehicular conservation methods (converting lamps to LED); fleet replacement and greening

Data Sources:

GHG Inventory:
Based on estimated fuel usage and emissions factors by fuel type
Still collecting internally measured data on energy usage/emissions

- **Electric bills**
- **Purchase records for various gases like acetylene**
- **Bulk re-fueling totals (fueling stations for Caltrans vehicles only)**

-Tracking gallons by fuel type
-Use of in-vehicle Voyager cards to purchase fuel when there is no bulk fuel station nearby

- **Tracking transition to different fuel sources and more energy efficient equipment (like biofuels and LED signals)**

External partners developing new data sources for planning:

- **Pacific Institute and NASA helping to investigate past trends in sea level rise and predict future impacts**
- **University of California-Davis creating "hotspots map" to identify transportation systems directly affected by the predicted sea level rise**

Comments: **Need a better internal tracking system for GHG inventory – some GHG sources are not well-tracked and completing inventory takes considerable time. Change will have to occur within Caltrans divisions. With a limited budget, a full inventory cannot be completed.**

Caltrans will work to effectively mitigate impending climate problems that were not anticipated in past transportation and regional plans.

Resources

[1] Caltrans Climate Action Program, http://www.dot.ca.gov/climateaction.htm

[2] Caltrans Office of Policy Analysis and Research, Climate Action Program, http://www.dot.ca.gov/hq/tpp/offices/opar/climate.html

[3] Climate Action Charter, October 2007, http://www.dot.ca.gov/hq/tpp/offices/opar/climate_files/Climate_Action_Charter.pdf

[4] 2009 California Climate Adaptation Strategy (http://www.climatechange.ca.gov/adaptation/)

[5] Heberger, M. (2009). The Impacts of Sea-Level Rise on the California Coast, Pacific Institute, Available at http://www.pacinst.org/reports/sea_level_rise/report.pdf

[6] Climate Action Program at Caltrans, December 2006 Report, http://www.dot.ca.gov/docs/ClimateReport.pdf

[7] California Climate Action Team Reports, http://www.climatechange.ca.gov/climate_action_team/reports/

[8] Caltrans Fleet Greening Program, http://www.dot.ca.gov/hq/eqsc/CleanAir/greenfleet.htm

[9] Addendum to 2007 Regional Transportation Plan Guidelines, http://www.dot.ca.gov/hq/tpp/offices/orip/rtp/index_files/Adopted_Addendum_to_the_2007_RTP_Guidelines.pdf

CASE STUDY

WSDOT

Climate Change Initiatives

What are WSDOT's Climate Change Initiatives?

WESTERN CLIMATE INITIATIVE

The Western Climate Initiative was initiated in February 2007 when the respective governors of Arizona, California, New Mexico, Oregon, and Washington signed an agreement to develop a market-based program and a regional-wide plan for reducing greenhouse gas emissions. Building upon the accomplishments and research of two previous regional efforts, the West Coast Global Warming Initiative started in 2003 and the Southwest Climate Change Initiative started in 2006, the WCI perfected a plan to reach their goals. It has become a collective collaboration between independent jurisdictions that work together to identify, analyze, and implement policies to mitigate climate change at a regional level. On January 29, 2009, Chris Gregoire, Washington governor, and other legislative leaders released a package that included an accountable cap-and-trade system that was built on the WCI design. It will be fully implemented in 2015, and will stand as the most comprehensive cap-and-trade program to date. The WCI design includes coverage over six main greenhouse gases in the United States, and it will cover nearly 90 percent of all GHG emissions in the United States and provinces of Canada by 2015. The program will be gradually transitioned into partner states in order to adapt to climate change impacts.

[http://www.ecy.wa.gov/climatechange/wci_stakeholders.htm]

WSDOT has compiled several initiatives and projects to address climate change within Washington State. High fuel consumption, air pollution and traffic congestion produce greenhouse gas (GHG) emissions which contribute to climate change. The Climate Change initiatives employ one or many approaches to reduce GHG emissions such as promoting more efficient vehicles and cleaner fuels, reduction of Vehicle Miles Traveled (VMT), and overall improvements to transportation system efficiency. Many of WSDOT's climate change initiatives are part of the agency's congestion mitigation program, Moving Washington. WSDOT is one of the first state DOTs to produce an emissions inventory, which is required of all Washington state agencies to measure progress towards emissions reduction goals. The reduction goals stem from Washington's involvement in the Western Climate Initiative. It is also involved in the multi-state West Coast Green Highway project. In addition to work at a strategic level, WSDOT also released internal project-level guidance in 2009 for incorporating climate change considerations into all SEPA or NEPA Environmental Impact Statements or NEPA Environmental Assessments [1].

Strategic Approach(es):

Laws & Directives

Collaboration

Sustainable Funding

Brief Description:

Implementation of projects to collectively monitor and reduce greenhouse gas emissions in Washington State while improving system quality and efficiency.

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How does Moving Washington address GHG emissions and climate change?

Moving Washington was developed as a ten year program to address the findings of a congestion performance audit of the Puget Sound region. The audit was completed in October 2007 by the State Auditor's Office. The purpose is to enhance mobility and improve future system efficiency by reducing congestion. WSDOT's approach to limiting congestion falls into three categories: (1) add capacity strategically, (2) operate efficiently, and (3) manage demand. By 2010, WSDOT had addressed 21 of the 22 audit findings through the Moving Washington program [2].

Add Capacity Strategically

WSDOT enhances the capacity of its road system by reducing the number of serious "traffic-flow bottlenecks". Many of the nearly 400 projects within the biennium transportation funding package for 2003 to 2005 increased system capacity to alleviate identified congestion zones. However, since simply adding more roads is not a long-term sustainable solution, WSDOT also explores multi-modal solutions. For example, the WSDOT Freight Plan suggests capacity improvements to rail facilities as well.

Operate Efficiently

In order to prevent system congestion, WSDOT implements innovative traffic technologies to maintain high system efficiency and safety.

Active Traffic Management (ATM)

ATM uses sensors embedded in the roadway to actively adjust speed limits on electronic signs according to road conditions. These dynamic signs also inform drivers of changes in the road conditions, such as accidents, and reroute drivers to prevent congestion from building up. For example, in the case of a rush hour traffic accident, the signs may reroute drivers to shoulder lanes. The system is scheduled to be tested along a six-mile span of I-5. ATM Construction began in May 2009, and electronic signs were expected to be operational by July 2010 [3,4].

High Occupancy Toll Lanes (HOT Lanes) Pilot Project

In January 2003, the Washington State Transportation Commission adopted a resolution directing WSDOT to evaluate the feasibility of a HOT Lanes Pilot Project. On May 3, 2008 the four-year SR 167 HOT Lanes Pilot Project opened. The Pilot Project converted 9 miles of existing HOV lanes on SR167 to HOT lanes. The lanes are intended to serve unmet capacity during peak hour periods. HOT lanes are generally free for HOVs and give single occupancy drivers the option to pay a variable, electronic toll to use them to avoid congested general purpose lanes. Variable tolls are determined by embedded road sensors which collect real time traffic data such as traffic speed and volume. Toll prices increase when traffic is heavy so that the HOT lanes do not become congested themselves. The HOT lanes are only accessible within access zones indicated by dashed lines on the road (Figure 5-19). The pilot project has shown improvements in traffic flow along SR167. A comparison of traffic in April 2007 to April 2009 showed that general purpose lane speeds increased 10% and volumes increased approximately 3% – 4%. Similarly, HOT lane speeds increased 7% – 8% and volumes increased about 1% – 3%. Based on the project performance after completion in May 2012, the legislature will determine if the southbound HOT lane will be extended to 8th Street East or if an HOV lane will be built instead [5,6].

Figure 5-19. HOT lanes configuration.
Source: http://www.wsdot.wa.gov/Tolling/SR167HotLanes/default.htm

Manage demand

By promoting alternative commuting methods to avoid single occupant vehicle commute, the system will be more efficient overall. Moreover, dynamic traffic signs and variable tolling (which changes to accommodate demand) will aim to equally distribute traffic to alleviate congestion. Transportation Demand Management (TDM) provides alternatives for commuters such as riding the bus or train, vanpools, and carpools to reduce single occupant vehicle traffic while at the same time increasing the carrying capacity of Washington's transportation system.

Commuter Trip Reductions (CTR)

The CTR program was created in 1991 by the Washington State Legislature as part of the Washington Clean Air Act. In 2006 the CTR Efficiency Act mandated the reduction of single-occupant vehicle trips and VMT through the development and implementation of new policies in counties with the highest automobile-related GHG emissions. CTR is managed by WSDOT, which staffs the CTR board, and the agency provides guidelines for cities, counties, and regional agencies to develop CTR plans. WSDOT provides funding and technical assistance to help jurisdictions and employers develop and implement CTR plans. This assistance includes training, supporting data collection and analysis, and maintaining networks of partners and documentations on best practices. CTR plans generally contain strategies for encouraging people to ride the bus, vanpool, carpool, walk, bike, work from home, or compress their workweek. Between 1993 and 2007 the approximately 1,100 worksites participating in the CTR Program saw a decrease in the "drive-alone rate" from 71 percent to 65 percent, respectively. During 2007 alone the CTR Program led to an estimated 18% decrease in traffic congestion. From 2007 to 2009, CTR achieved an average reduction of 28,000 weekday vehicle trips each morning. This equated to reduced consumption of about 3 million gallons of fuel. As shown in Figure 5-20, the trip reduction did not hurt economic activity in Washington. In fact, employment rose from 1995 to 2007.

In 2007 the state legislature approved Growth and Transportation Efficiency Centers (GTECs) as a specialized part of the CTR. Whereas the CTR addresses the commuters working for major employers, the GTCEs offer smaller-scale commute alternative programs to growing neighborhoods, schools, and business within densely populated zones in the state. From 2007 to 2009 CTR worksites within GTECs had the greatest decrease in VMT (11.0%) compared to all the CTR sites. Overall, CTR contributed to a 2.8% reduction in VMT during that timeframe. In the Central Puget Sound Region, fewer vehicles during rush hour has equated to a reduction of 62 million VMT and 12,900 hours of delay annually [7,8,9]. WSDOT maintains 14 years worth of CTR data that WSDOT, local jurisdictions, and transit systems use to develop their plans and to conduct future planning.

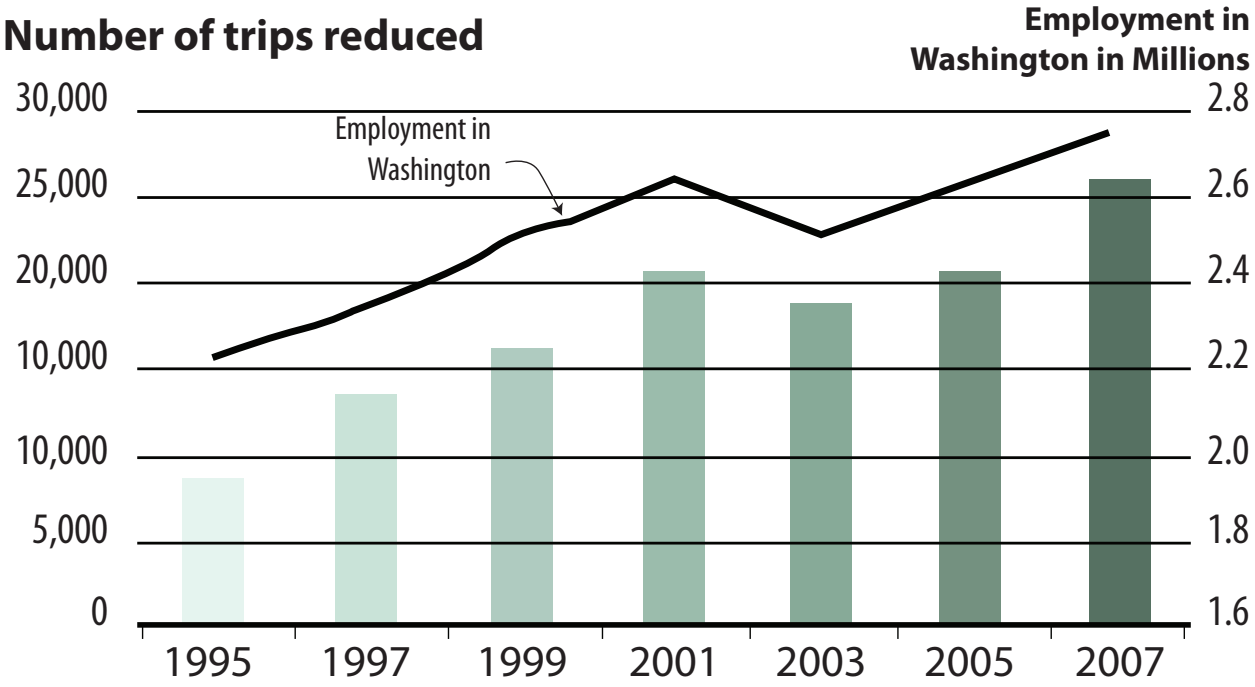

Figure 5-20. Number of Vehicle Trips Reduced at CTR sites and Employment in Washington. Source: CTR 2007 Report.

Trip Reduction Performance Program (TRPP)

Created in 2003 by the state legislature, the TRPP is an incentive for "entrepreneurs, private companies, transit systems, local governments, non-profit organizations, developers and property managers to provide services to employees that result in fewer vehicle trips arriving at worksites [10]." Companies submit proposals to lower single occupant vehicle trips of their employees and funding is awarded to those projects which meet the preliminary quota. From 2007-2009 approximately $1.5 million were allocated for the TRPP to eliminate about 4,271 commute vehicle trips from Washington State highways each day [10,11].

Vanpool Investment Program

The Vanpool Investment Program was created by the Washington State Legislature in 2003, and was implemented by WSDOT. A ten year investment program of $30 million was developed in 2003 to increase the vanpool program statewide, doubling the number of operating vanpools to about 3,180 by 2013. These funds are designated only for public transit agencies and can only be used on capital costs associated with putting new vans on the road or for incentives for employers to increase employee vanpool usage. Vanpool ridership

Figure 5-21. West Coast Green Highway (Source: WSDOT website)

increased approximately 41% from 2003 to 2008; however, since 2008 vanpool ridership has been declining due to the economic downturn as employees lose or change jobs vanpools struggle to keep enough riders to continue. Additionally, many employers have been forced to reduce transportation funding, including vanpool subsidies, and further limiting vanpools [12].

How does West Coast Green Highway (WCGH) address climate change?

The West Coast Green Highway will span a total of 1,350 miles of Interstate 5 (I-5), traveling from the U.S. border with Mexico through California, Oregon and Washington, reaching Canada (route shown in Figure 5-21). It will promote low and zero-carbon-emitting vehicles which should increase the demand for more efficient vehicles; this would result in a reduction of dependency on foreign oil and transportation related GHG emissions. The WCGH will include alternative fuel infrastructure such as electric vehicle charging stations which will encourage commuters to travel in cars which support alternative fuels. Other alternative fuels which the WCGH may support include hydrogen, and biodiesel. Since transportation accounts for 47% of all of Washington's GHG emissions (making it the largest source of GHG emissions in the state) the change from standard to alternative fuels will drastically reduce GHG emissions within Washington and the U.S. to meet both state and national standards. The WCGH project will also incorporate advanced highway technology such as traffic management systems which coupled with the alternative fuel incentives will lead to a more efficient and environmentally sustainable highway system [13].

The Green Highway Project was stimulated by a Governor's Executive Order (#09-05 "Washington's Leadership on Climate Change"), which included a directive to develop a plan and seek federal funding to electrify the West Coast interstate highway and metropolitan areas along the route. It was intended as a collaborative effort among the states of Washington, Oregon, and California. Two subsequent legislative efforts in 2009, both concerning electric vehicles, support the Green Highway Project - Washington State House Bill 1481 and RCW 47.38.070 Electric Vehicle Infrastructure. The project is being pursued with several initiatives including the NewMobility Hubs, a Solar-powered Highway, and an Alternative Fuels Corridor.

NewMobility Hubs

NewMobility Hubs will incorporate cutting edge technology like RideshareOnline, vehicle charging and mobile in-vehicle communication systems to transform existing park and ride lots and transit centers into high-tech, multi-modal hubs. WSDOT has teamed with Microsoft, Inrix, Ford, Cascadia, University of Washington, and others to create the NewMobility Hubs [13].

Solar-powered Highway

The first "solar highway" in the US is located on the West Coast Green Highway at the intersection of I-5 and I-205 in Oregon. The intersection is lit with clean, renewable, and secure energy from 594 solar panels. WSDOT is using lessons learned in Oregon to investigate solar and wind-power technology to meet sustainability goals and reduce energy costs. WSDOT uses solar power to illuminate remote facilities and power electronic message signs. The agency is investigating the feasibility of using sun or wind to power traffic lights, cameras, facilities, safety rest areas, and even electric vehicle charging stations [13].

WSDOT Alternative Fuels Corridor Economic Feasibility Analysis

Completed in February 2009 this economic analysis includes background information on different fuels' supply chains, estimated station costs and expected station revenues for alternative fuels (AF) to be sold in the I-5 corridor. Within the analysis four categories were

considered to establish the feasibility of integrating AF infrastructure into the I-5 corridor, including AF supply chain assessment, station spacing analysis, operating feasibility, and alliance opportunities. In order for AF infrastructure to be viable there must be an ensured commitment from legislative bodies, private investor companies (such as automotive companies which invest in AF vehicle production) and future users of the system: the consumers [13].

How did WSDOT complete a GHG Emissions Inventory?

Data Need:

Purpose is to enhance mobility and improve future system efficiency by reducing congestion; goals fall into three categories: (1) add capacity strategically; (2) operate efficiently, and (3) manage demand

Data Sources:

Internal plans and data:

- **Data on commute reduction programs - report VMT reduction and fuel savings based on individual and employer data**
- **WSDOT maintains database of CTR data to be used by the agency, local jurisdictions and transit providers for future planning**
- **Collect number of active vanpools, number of new vans purchased for use**
- **HOT lanes pilot project: measured before and after travel speeds and estimated volumes in the HOT lane and general purpose lanes**
- **Complete GHG emissions inventory using utility payments (rather than direct measure of energy use)**

Comments: **Progress measured in terms of contribution to state's emissions reduction goal; lack of specific performance goals and measures**

As mandated by the 2008 Washington State climate change legislation WSDOT's GHG emissions were above allowed thresholds of 2,500 metric tons (MT) of carbon dioxide equivalents (CO2e) for vehicle fleets and 10,000 MT CO2e in total. WSDOT must therefore report GHG emissions released through agency activities, including existing ferry and highway systems as well as from agency buildings and vehicles. The 2007 GHG Emissions Inventory was calculated following The Climate Registry's General Reporting Protocol to a limited extent. It was calculated from information on utility payments that the WSDOT makes rather than direct utility use. This estimated 2007 GHG Emissions Inventory (a snapshot shown in Figure 5-22) does not take into account utilities within rent payments for leased space, but, for the 2010 report, WSDOT is working on quantifying utility use for which payments are not made directly by the agency. The 2007 GHG Emissions Inventory serves as a baseline comparison for future reports. In the future, the agency will be able to track and reduce its GHG emissions to address its climate change impact, which may lead to savings in operation costs [14].

CLIMATE REGISTRY

The Climate Registry was founded when several states became interested in establishing state and regional GHG registries. States believed that this data would dramatically help the planning process to deal reducing GHG emissions. The climate registry is the largest initiative in the United States, and North America, including over 80% of the US population, Canadian provinces, and some Mexican states and Indian territories and tribes. It is critical that the information is very precise, so independent third-party verification is required when states submit their registries. All data is also available to the public to ensure that nothing is being withheld. Any organization can participate in the Climate Registry, and potentially save money on energy and be recognized as a global environmental leader. The first step is to gather data on an annual basis, and input that data into a web-based software. That data is then approved by a third-party verifier annually. If verified, the data will be displayed publicly on the Climate Registry website and any other information you wish to provide with it if necessary.

http://www.ecy.wa.gov/climatechange/registry.htm

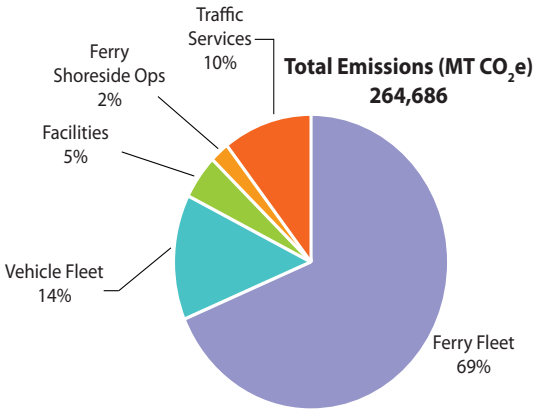

Figure 5-22. 2007 WSDOT GHG emissions: Total Emissions (L), Emissions by Category (R). Source: 2007 WSDOT GHG Emissions Inventory

Resources

[1] Guidance for Project-Level Greenhouse Gas and Climate Change Evaluations http://www.wsdot.wa.gov/NR/rdonlyres/73ADB679-BDA6-4947-93CA-87C157862DD7/0/WSDOTprojectLevelGHG.pdf

[2] http://www.wsdot.wa.gov/Congestion/default.htm

[3] http://www.wsdot.wa.gov/Projects/I5/ActiveTrafficManagement/default.htm

[4] http://www.youtube.com/watch?v=cd0doR0Ga-I

[5] http://www.wsdot.wa.gov/Projects/SR167/HOTLanes/Default.htm

[6] http://www.wsdot.wa.gov/NR/rdonlyres/31FB3D24-79CC-4332-82F7-EBECEBE1CA71/0/HOTLanesAnnualReport2009.pdf

[7] http://www.wsdot.wa.gov/TDM/CTR/CTRworks.htm

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[9] http://www.wsdot.wa.gov/NR/rdonlyres/0634C604-D81A-43EA-98D4-78FF07A1E4FE/0/CommutTripReductio2009ReportWeb.pdf

[10] http://www.wsdot.wa.gov/TDM/TRPP/

[11] http://www.wsdot.wa.gov/TDM/TRPP/SelectedProjects.htm

[12] http://www.wsdot.wa.gov/NR/rdonlyres/78774733-2E96-48E3-9CEC-237C5B1848BA/0/Vanpool.pdf

[13] West Coast Green Highway: http://www.wsdot.wa.gov/Partners/GreenHighways/

[14] WSDOT 2007 GHG Emissions Inventory: http://www.wsdot.wa.gov/NR/rdonlyres/A9F-D1AD6-94C1-49D9-85E5-A45815D670BD/0/WSDOT_2007_GHG_Inventory.pdf

CASE STUDY

London Sustainable Freight Distribution Plan

Strategic Approaches:

Collaboration
Targets

Brief Description:

The London Sustainable Freight Distribution Plan identifies the challenges posed by the growth of London and climate change, and details how freight transportation intersects with both challenges. The Plan explains the strong need for partnership among public and private entities to achieve a vision of sustainable freight distribution, and proposes actions for addressing the challenges. The Plan also reveals the shortage of freight data and outlines a strategy to collect better data. In order to monitor progress on proposed actions, the Plan includes performance measures and a framework for annual reporting.

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Why is London concerned about Freight Planning?

By 2025, planned population growth in London is expected to increase demand for freight and servicing by 15 percent. This growth will likely lead to worse congestion and contribute to climate change unless the transportation sector is prepared to deal with it. Transport London recognizes that proactive measures and partnerships with freight operators are necessary for a sustainable freight system. The foundation of the London Sustainable Freight Distribution Plan can be found in the national report Sustainable Distribution: A Strategy. This report was published by the former Department of Environment, Transport and the Regions in March 1999 and reissued by the Department for Transport in January 2004 [5]. The premise of the report is that growth in the freight industry should not be at the expense of sustainable development, or the needs of economy, environment and society. The Mayor's Transport Strategy (released in 2001) also recognizes the important role freight plays in supporting the economy and that growth would create competition for space among freight modes and other transportation services. In 2005 the London Sustainable Distribution Partnership (LSDP), a group charged with identifying strategic freight investments for London, established the following vision for sustainable freight distribution in the city:

> *"…the safe, reliable and efficient movement of freight and servicing trips to, from, within and, where appropriate, through London to support London's economy, in balance with the needs of other transport users, the environment and Londoners' quality of life…"*

Transport for London coordinates the LSDP and also takes a specific role in promoting efficient freight transport practices that support London's economic development; maintain London's local, inter-regional and world city role; and contribute to reducing the environmental impact caused by freight in London.

Definition - Sustainable Freight Distribution

The balanced management and control of the economic, social and environmental issues affecting freight transport that:

- **Complies with or exceeds environmental standards, regulations or targets aimed at reducing emissions of climate change gases, improving air quality and minimizing impacts from accidents, spillages or wastes**
- **Ensures freight is run efficiently, reduces unnecessary journeys, minimizes journey distances and maximizes loads with effective planning**
- **Complies with labor, transport and human rights standards and regulations ensuring that employees and communities affected by freight can function in a healthy and safe environment**
- **Minimizes the negative impacts of freight activities on local communities**

How will the vision for sustainable freight distribution be achieved?

In order to achieve LSDP's vision for London's freight system, Transport for London (TfL) embarked on a strategic freight planning study. The freight study was intended to "improve the sustainability of London's freight distribution in balance with the needs of other network users… to reduce capacity used by road freight vehicles (particularly in peak periods) and to improve the economic, environmental & social efficiencies of the remaining road freight vehicle movements" [2]. In January 2008, TfL published its findings and recommendations in Sustainable freight distribution: a plan for London. The report is organized into three sections. The first section outlines the vision and policy context for the Plan. The second section identifies operational challenges for freight by mode and by sector. The last section details plan delivery, including proposed projects, a monitoring framework, and funding sources.

The Plan explicitly lays out seven goals in terms of sustainable development:

Economy
- Support London's growth in population and economic activity
- Improve the efficiency of freight distribution in London
- Balance the needs of freight and servicing with those of other transport users and demands for London's resources

Environment
- Tackle poor air quality and freight's contribution to climate change by reducing emissions of air pollutants and CO2 caused by freight
- Improve quality of life in London by minimizing the impact of noise and vibration caused by freight distribution

Society
- Improve health and safety in London by reducing the number of deaths and injuries associated with freight movement
- Improve quality of life in London by reducing the negative impacts of freight on communities.

While the Freight Plan lacks statutory force, it has been developed to support the Mayor's Transport Strategy which is a statutory document describing the city's future spatial pattern. In addition, it will have considerable influence at the local level because it will inform boroughs' Local Implementation Plans and Development Plan Documents (DPDs) and the implementation of traffic authorities' Network Management Duty Process. Additionally, the Plan emphasizes partnerships among public and private entities to achieve development goals and maintain competition in freight distribution.

To support effective partnerships, the roles of different stakeholders are communicated through supporting documents like:

- London Rail Freight Strategy,
- Operators' Guide,
- Borough Freight Toolkit,
- Annual London Freight Data Report,
- Annual progress reports, and
- On-going workshops and reports from the workstreams.

Freight Planning and Climate Change

Despite its positive contribution to the economy, TfL recognizes that freight is a key contributor to greenhouse gas emissions and climate change. Based on 2006 data, the estimated contribution from freight transport in London contributes an estimated 2.2 million tons of carbon dioxide (CO2) emissions, which represents 23 percent of the total for ground-based transport and 5.1 per cent of the city's CO2 production and energy use (illustrated in Figure 5-23).

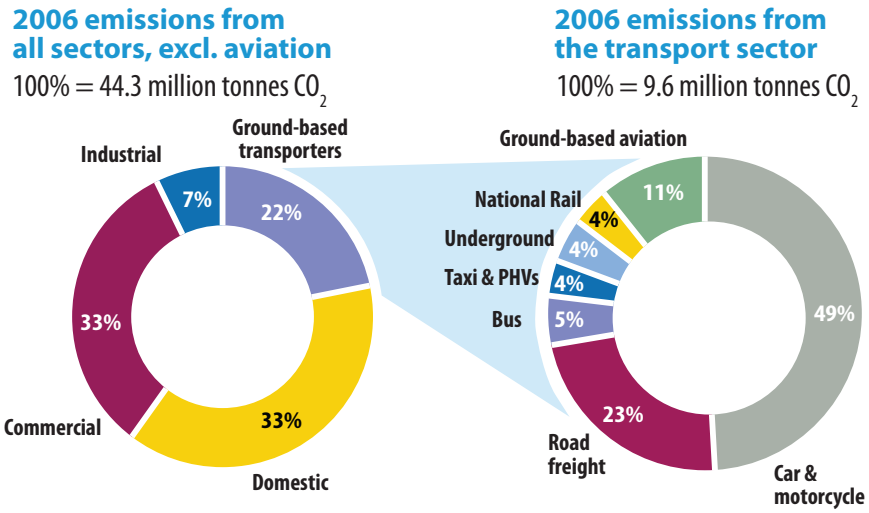

Figure 5-23. 2006 CO2 emissions from the transport sectors. Source: Mayor of London (2007) Action Today to Protect Tomorrow, The Mayor's Climate Change Action Plan

Because freight is such a large contributor to climate change, it provides a great opportunity to reduce emissions. Detailed analysis in the Freight Plan suggests that up to 1.21 million tons per year of CO2 could be saved from the freight sector by 2025.Table 5-12 shows where CO2 savings could come from. Because many of the opportunities are out TfL's hands, the Plan recognizes that freight operators have a significant role to play in supporting the climate change agenda by adopting green fleet management [1].

Table 5-12. Potential freight CO2 savings (million tons) by 2025.

Opportunity	Million tonnes CO_2 per year saved using travel plan and procurment links	Reduced CO2 per year saving without travel plan or procurement links
Road User Charging (should it be pursued as part of a national scheme)	0.20	0.20
Modal Change	0.08	0.00*
Fleet Efficiency	0.29	0.06
Out of hours deliveries	0.01	0.00*
Construction Consolidation	0.13	0.00*
Retail/Office Consolidation	0.10	0.00*
Waste Fleets	0.002	0.00*
Voluntary adoption of alternative fuel and low carbon vehicles	0.20	0.10
Biofuels	0.20	0.10
TOTAL	1.21	0.46

Source: London Sustainable Freight Distribution Plan

What strategies does the Freight Plan suggest?

The London Sustainable Freight Distribution Plan identifies four projects to be completed from 2008 to 2018. The Plan quantifies the economic, environmental, and social impacts of each project and establishes specific milestones over the 10-year period. It also defines roles and responsibilities for accomplishing each milestone. The overall investment in the first three years of the implementation program could range from £150m to £450m, with TfL contributing between 20 and 40 percent of this total.

The four projects are as follows:

Project One - Freight Operator Recognition Scheme (FORS) will provide incentives for private freight operators to reduce CO2 emissions and accident rates. A FORS participant will receive a "membership level" (either bronze, silver or gold) based on how well it addresses fleet and freight vehicle operational efficiency and reduces CO2 emissions, congestion, collisions and operator costs.

Project Two - Delivery and Servicing Plans (DSPs) will be used to increase building operational efficiency by reducing delivery and servicing impacts to premises, congestion and collisions. DSPs will be contractual relationships between building operators and their supply chain that specify a commitment to sustainable freight distribution. DSPs will likely involve FORS membership, assurance of legal loading locations, and approaches to reduce delivery trips, particularly during peak periods. TfL and the GLA Group will demonstrate implementation of DSPs for their own premises, and provide guidelines for the boroughs to create their own plans. DSPs will also be linked to planning conditions for major new developments.

Project Three - Construction Logistics Plans (CLPs) are similar to DSPs but will be applied to the design and construction phases of facilities. Example initiatives include reducing lane closures and travelway restrictions and reducing construction duration. As with DSPs, TfL and GLA Group will model implementation of the plans for their own construction projects.

Project Four - Freight Information Portal will provide London with a single interface for information on freight between London's public authorities and freight operators. The project is intended to reduce operators' administrative costs and improve access to freight journey planning in the city, to support improved operational efficiency, better driver behavior and the use of alternative fuels (including bio-fuel) and low-carbon vehicles.

The four projects described above will be supported by the implementation of three "workstreams":

Workstream 1 - Partnership development will be facilitated at pan-London and sub-regional levels to help coordination between TfL, businesses, operators and boroughs. A particular goal of the partnerships will be to identify and demonstrate best practices for reducing CO2 emissions and improving safety. Also, partnerships will be very important for securing funds to accomplish the plan. Transport London will be able to leverage funds from public agencies, businesses, and freight operators, all of whom have a stake in sustainable freight movement.

Workstream 2 - Major projects will focus on promoting modal change from road to more sustainable alternatives (such as rail and water), and on reducing CO2 emissions.

Specific projects will be developed as they arise and as funding is secured.

Workstream 3 - Data, modeling and best practices will be needed to build the freight knowledge base and build a business case for changing freight practices and infrastructure development.

As mentioned earlier, the Sustainable Freight Distribution Plan supports the Mayor's Transport Strategy and the Climate Action Plan. As such, future versions of the Mayor's Transport Strategy will include cross-modal freight strategies. In the long-term it will tackle congestion, changing the balance between freight modes, and deploying technology to improve freight operations [1].

What are preliminary outcomes from the Sustainable Freight Plan?

Progress toward the vision is going to be reported annually by seven main "progress measures" that reflect the three areas of sustainability: economy, environment, society. Additional measures will be added under each main measure as data sources are developed. The seven measures are:

- Total number of commercial vehicle parking-related violations per million freight vehicle kilometers
- Overall reliability measure for freight
- Emissions impact of freight road vehicles, notably CO2, particulates and NOx emissions
- Freight fly-tipping (or illegal waste dumping) incidents
- Overall number of people killed or seriously injured in collisions involving freight vehicles
- Number of thefts linked to freight activities on London roads
- FORS membership at each level

The first annual Data Report was released in 2008 and used 2007 data to create a base line for future progress reports.

The TfL Sustainable Freight Distribution Program is TfL's contribution to delivering the plan. It is funded at £4m per year to 2018 within the current TfL Business Plan. It achieves a monetized benefit cost ratio of 2.4:1 based on forecast journey time savings, CO2 and injury reduction. As of March 2009, four out of five sub-regional Freight Quality Partnerships (as prescribed by Workstream 1) were set up and TfL was in the process of appointing managers for each of them. In addition, FORS reached 40,000 vehicles on 23 November 2009 and covered an estimated 12 per cent of the commercial freight vehicles working in London. While the workstreams were progressing slower than anticipated, TfL was still optimistic about reaching its 2018 program goals [4].

A post-analysis of the London Sustainable Freight Distribution Plan [2] provides important "lessons learned" for agencies that may be interested in a similar process. A few learning points are given below:

- To enable key gatekeepers to be influenced, undertake activity to understand the issues from different perspectives to help design the Plan and the supporting communication activity.
- Align the Plan with existing initiatives where possible, to simplify the offering to help accelerate Plan uptake.
- Public sector procurement can be used to change freight market conditions.

- Establishing ongoing monitoring processes and revising forecasts are essential activities.

The analysis also reported several key results for FORS members 18-months after the program's launch:

- Overall deliveries reduced by 20%
- Catering supplies deliveries reduced by 40%
- Archives/records deliveries reduced by 40%
- Stationery supplies deliveries reduced by 40%
- 33% of all deliveries made by FORS registered operators
- Significant increase in materials' recycling and reduction in waste generated
- Contracts re-tendered and savings made.

Resources

[1] Transport for London, Sustainable freight distribution: a plan for London, 2008 http://www.tfl.gov.uk/microsites/freight/documents/London-Freight-Plan.pdf

[2] Steele, S. (2009). Practical Steps for City and Region Authorities Promoting Sustainable Freight Distribution – Lessons from the London Freight Plan, http://www.etcproceedings.org/paper/download/4168 9/10/2009

[3] Transport for London, 2010, London Freight Plan Website, http://www.tfl.gov.uk/microsites/freight/london_freight_plan.aspx#plan

[4] Transport for London Freight Unit, March 2009, Transport and Environment Committee (TEC) "London Councils TEC Paper March 2009", Available at www.londoncouncils.gov.uk/London%20Councils/Item8.FreightQualityPartnerships180309App1.doc

[5] UK Department for Transport, 2010, Freight, http://www.dft.gov.uk/pgr/freight/

Data Need:

Plan lays out seven sustainability goals that fall under the categories:
-economic: improve efficiency of freight; balance needs of freight with other transport users
-environment: reducing freight's contribution to climate change by
-society: improve quality of life and safety in London

Data Sources:

Internal data

- **number of commercial vehicle parking-related violations**
- **incidents of illegal freight dumping**
- **reduction of noise and vibrations to improve quality of life**
- **accident reduction to improve safety**

External partners: private freight operators partner with city in the Freight Operator Recognition Scheme which encourages freight operators to reduce CO2 emissions and accident rates

Comments: **Highly successful program that incorporates many private freight operators; some quality-of-life and environmental standards have few measurement methods**

CASE STUDY

WSDOT

Freight Planning

Why is WSDOT concerned about freight?

Stategic Approach(es):

Collaboration

Brief Description:

The Freight Report considers freight movement as a vital economic concern for statewide planning. It explores freight movement on three levels: "Global Gateways", "Made in Washington", and "Delivering Goods to You." Following up on the Freight Report, WSDOT embarked on an in-depth rail plan to identify needs, vision and goals, and benefits to society. The goals of the freight plans are sustainability-oriented.

Freight is a national concern and WSDOT is being proactive with planning in order to position itself for future state and federal investments in the freight system. Freight is also a big and vital industry in Washington, as shown by the value of freight shipments in Figure 5-24.

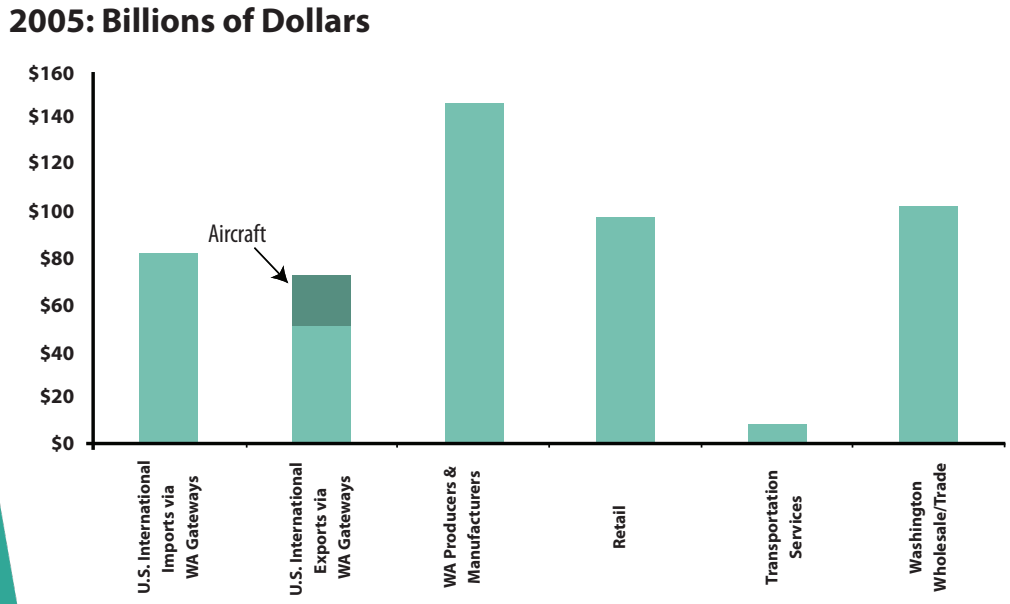

Figure 5-24. Washington State Value of Freight Shipments. (Source: Washington State Transportation Plane Freight Report)

WSDOT's Freight Division is responsible for trucking, rail, and marine freight movement in three ways:

- Developing the state's strategic investment plan for freight, which is based on the Washington Transportation Plan (WTP) Freight Report.
- Building regional participation and support for the freight investment plan by working together with freight system partners.
- Managing the state's freight and passenger rail capital programs and operations.

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How has WSDOT planned for freight system improvements?

As part of the Washington Transportation Plan for 2007-2026, the Freight Systems Division completed a Freight Report that identified challenges and strategic investments for improving freight movement within and through the state [1]. The Freight Report is a multi-modal study focusing on roadway, rail, water, pipeline, and air transport. The report analyzes original research and existent information about Washington State freight customers to inform decision makers on:

- who the customers are in the state's freight system,
- why freight customers matter in terms of jobs and contribution to Gross State Revenues,
- what performance the customers expect from the freight system,
- where key performance gaps are located, and
- how decision makers may make the most productive strategic investments in Washington State's freight system.

Washington Transportation Plan (WTP)

WTP is a data-driven process that leads to Transportation Commission prioritization of investments into high, medium, and low priority. The WTP looks at the transportation system as a whole to determine strategic future investments based on the data analysis for each sector of the system. This analysis is then compared to realistic levels of transportation funding in Washington and plausible projects are set for implementation over the next ten years.

The freight planning process started with data collection on population, freight movement, economic impacts, traffic conditions, highway features that may impede truck movement, and detailed rail freight statistics. The Freight Division then used GIS files to map the freight network and key resources. The planning process also involved extensive stakeholder outreach. From February to October 2004, the Freight Systems Division completed over 150 one-on-one interviews with high-volume shippers and carriers across the state to identify their requirements of the freight system. They also held numerous focus groups with state, regional, local, and federal partners. To follow up on initial findings, WSDOT commissioned Hebert Research, Inc. to conduct a statewide phone survey. In May 2004, Herbert Research interviewed 347 businesses representing a wide range of industries (an 82.4% response rate). WSDOT used statistical analysis to determine "industry satisfaction ratings" of current freight system performance, prioritize the single most important infrastructure or operational requirement (by region), define "on-time" service, estimate the percent of time spent incurring additional expenses to recover from shipping problems, and identify methods of transporting products to final market and of receiving inputs.

In the final report, WSDOT organized the freight system into three levels:

- Global Gateways – International and National Trade Flows Through Washington.
- Made in Washington – Regional Economies Rely on the Freight System.
- Delivering Goods to You – The Retail and Wholesale Distribution System.

The report explores trends, challenges, and priorities at each level and discusses interactions between different freight modes (for example, trucks stuck in congestion on highways can lead to delays in air cargo system). Based on all of the analysis, WSDOT identified twelve "highly productive investments" in the freight network to deal with identified bottlenecks and weather or maintenance-related deficiencies in the system. Washington State's freight planning is a best practice because it examines how the freight system impacts the environment (emissions, dredging waterways), the economy (manufacturers

and freight companies), and society (way-of-life for Washingtonians who rely on freight-related industries and Tribal Freight Needs).

In addition to the DOT's efforts, Washington provides a good example of regional freight planning. To support its regional transportation plan update, Transportation 2040, Puget Sound Regional Council conducted detailed freight analyses in four areas: truck values of time, operating costs, speeds, and performance measures. The primary findings were:

- Local or statewide data collection must occur to improve the value of time estimates for different truck types.
- Operating costs for trucks can be separated in regional travel demand models to represent real differences in costs for passenger cars and trucks.
- Speed data for cars and trucks can be determined from existing data sources.
- Quantitative performance metrics can represent the full range of planning objectives for freight.
- Benefit-cost analysis can separate the freight and passenger benefits for any project or program.
- Truck counts were compiled to assist in the validation of the truck model for use in regional planning.

PSRC's research will improve the regional travel model's ability to plan for freight and be incorporated into the Congestion Management Process.

WSDOT's Freight Rail Plan

The State Freight Rail Plan, released in December 2009, is an update of the 1998 plan. It establishes a new 2030 Vision for Freight Rail in Washington State:

The Washington State freight rail system is a reliable, cost effective, energy efficient and environmentally-friendly transportation mode for domestic and international cargo deliveries.

The study for freight rail was a "fact-based and data-driven" process. WSDOT strengthened its data collection and analytical capacity and developed improved databases and forecast models to evaluate the needs of the freight rail system better. Economic impact assessment, benefit/cost analysis, and cross modal comparisons link investments to their effects on the economy and society/environment. Further, as a critical part of Washington's multimodal transportation system, the rail system leverages intermodal connections to:

- Provide a seamless system for cargo deliveries to customers,
- Improve the mobility of people and goods, and
- Support Washington's economy by creating and sustaining family-wage jobs and livable communities.

The Freight Rail Plan describes the state's role and investment policies for freight rail, identifies "emerging issues" for infrastructure and operations, and recognizes data gaps. In addition, it monitors measures related to freight infrastructure in the Gray Notebook (see Case Study on page 101). Completion of the State Freight Rail Plan update will qualify Washington for federal grants authorized through the Passenger Rail Investment and Improvement Act of 2008 (PRIIA).

Another important aspect of the State Freight Rail Plan is that the process was stakeholder-driven. In May 2009, members of advocacy organizations, cities, counties, federal agencies, railroads, metropolitan planning organizations, ports authorities, regional transportation planning organizations, tribes, other state agencies, and other WSDOT offices were invited to participate on an advisory committee. The role of this committee was to (1) help develop the vision and goals of the State Freight Rail Plan; (2) provide assistance to update information for the freight rail system, capacity, and needs; (3) help identify and assess port access and rail abandonment issues; (4) help assess and evaluate beneficial impacts of rail infrastructure improvements on society; (5) help WSDOT understand concerns of local communities and organizations; and (6) share information.

Goals established by the Advisory Committee

Economic Competitiveness and Viability: Support the state's economic competitiveness and economic viability through strategic freight partnerships.

Preservation: Preserve the ability of the state's freight rail system to efficiently serve the needs of its customers as well as preserve the potential of the system in the future.

Capacity: Coordinate the freight rail system capacity increases to improve mobility, reduce congestion, and meet the growing needs of the state's freight rail users, when economically justified.

Energy Efficiency and Environmental: Take advantage of freight rail's modal energy efficiency to reduce the negative environmental impacts of freight movement in the state.

Safety and Security: Address the safety and security of the freight rail system and make enhancements, where appropriate.

Livability: Encourage livable communities and family-wage jobs through the freight rail system and its improvements.

As part of the planning process, WSDOT and the Advisory Committee developed a benefit/cost methodology to evaluate state projects against the six legislative priorities for Washington's transportation system:

- Economic, safety, or environmental advantages of freight movement by rail compared to alternative modes.
- Self-sustaining economic development that creates family-wage jobs.
- Preservation of transportation corridors that would otherwise be lost.
- Increased access to efficient and cost-effective transport to market for the state's agricultural and industrial products.
- Better integration and cooperation within the regional, national, and international systems of freight distribution.
- Mitigation of impacts of increased rail traffic on communities.

In addition to the involvement of the Advisory Committee, a Public Open House was held to review the draft plan.

WSDOT's Freight Partnerships

In addition to its own planning efforts, WSDOT also participates in notable public private partnerships. The Regional Freight Mobility Roundtable is a nationally recognized public-private forum to define and recommend actions serving freight mobility needs in and through the central Puget Sound region. WSDOT joins other public sector participants like local governments, the ports of Seattle, Tacoma and Everett, state agencies, USDOT (including rail, highway, maritime divisions) and the Department of Defense. Private sector participants include rail, marine, air cargo and trucking carriers, and shippers such as Boeing and Weyerhaeuser. The Roundtable provides input for state and regional transportation plans.

WSDOT was also an original partner in the Freight Action Strategy (FAST) Corridor Program. FAST is an innovative partnership that is working to improve the movement of freight along the Everett-Seattle-Tacoma corridor. The partnership consists of local cities,

ports, counties, the trucking industry, the BNSF Railway and UP Railroad, economic development organizations, and business interests. Since its inception in 1996, the FAST partnership has helped to leverage $568 million for 25 improvement projects that will benefit passenger and freight mobility and safety in the central Puget Sound. As of 2010, nine FAST projects have been completed [2].

What progress has WSDOT made since releasing the Freight Plan?

WSDOT has continued research and planning efforts to support its goals for the Freight System. The agency has completed long-term studies for each of the modes (Web links available in the references section) and developed new data and modeling resources for future planning efforts. In 2007, the DOT enlisted researchers at Washington State University to work on a State Freight Data System. The purpose of the study was to gather local, state, and national data sources and identify gaps and areas for future development. As part of the State Freight Data System, WSDOT would like to maintain a database and have an interface with state data users.

WSDOT has completed another data related study: Development and Analysis of a GIS-Based Statewide Freight Data Flow Network. The purpose of the work was to improve state freight's resiliency by modeling supply chain freight flows after disruptions like traffic accidents and weather events. Researchers completed a Geographic Information System (GIS) based model that represents the state's freight highway, arterial, rail, waterway, and intermodal network. The model will enable WSDOT to accurately predict how companies will route shipments during a disruption and can help the state prioritize strategies that protect industries most vulnerable to disruptions [3].

Another project is the Washington State Truck Freight Performance Measure Research. The study used on-board-truck Global Positioning System (GPS) location reads to document where truck trips began, where they went and how long it took them to get there. The method was used to monitor a known truck bottleneck and for before and after monitoring of truck speeds for a bridge improvement project. By being able to accurately track truck trip travel times and network reliability, WSDOT feels the research deliverables put the state at a great advantage for the following [4]:

- Future federal freight funding requests,
- Monitoring freight emissions for EPA,
- Increasing public accountability to citizens, and
- Identifying key bottlenecks and prioritizing project funding.

In 2008, WSDOT completed work with Massachusetts Institute of Technology to investigate Freight System Resiliency (FSR). The study looked at how the state freight network can respond to and recover economically from natural or man-made disaster. It resulted in a plan for the state that complements the existing emergency response plans. The FSR plans how WSDOT should monitor, manage, and control its transportation network assets and work with private sector partners to improve the resiliency of the entire network [5].

Data Need:

The Advisory Committee established goals: economic competitiveness and viability; preservation of states rail system; capacity coordination to improve mobility; energy efficiency and the environment; safety and security; and livability to support communities and jobs through the rail system

Data Sources:

Internal Sources

- **freight division uses GIS files to map the freight network and key resources**
- **freight performance measured using onboard GPS tracking of speeds**
- **Stakeholder outreach to public and private divisions such as local governments, USDOT, Department of Defense, and rail marine, air cargo, and trucking carriers such as Boeing and Weyerhaeuser**

External sources

- **Amtrak passenger rail reports**
- **MIT Center for Transportation and Logistics study for Development of a Statewide Freight System Resilience Plan**

Comments: **Study integrates data from a wide variety of sources to form a comprehensive plan; Several quality-of-life and environmental goals are difficult to measure**

In addition to the freight rail plan, WSDOT conducted analysis on each of the freight modes (see Resources for documents). Using the results of these follow-up studies, WSDOT published a map and description of state freight priorities in March 2010. The map identifies bottlenecks in different modes and recommends specific projects to solve the problems.

Resources

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Modal Freight Reports:

Washington State 2010-2030 Freight Rail Plan, http://www.wsdot.wa.gov/Freight/Rail/Plan.htm

Washington State Long-Term Air Transportation Study, July 2009, http://www.wsdot.wa.gov/aviation/LATS.htm

2009 Marine Cargo Forecast Technical Report , March 2009, http://www.wsdot.wa.gov/Freight/Marine.htm

Highway System Plan Technical Update 2007-2026, December 2009, http://www.wsdot.wa.gov/planning/HSP.htm

Amtrak Cascades and WSDOT, March 2010, http://www.wsdot.wa.gov/Freight/publications/PassengerRailReports.htm

CASE STUDY

Life Cycle Analysis:

Sustainability

Why should transportation agencies consider life cycle costs?

Strategic Approach(es):

Sustainable Funding

Brief Description:

Life Cycle Cost Analysis (LCCA) is a common approach for assessing long-term economic costs of transportation alternatives and is used extensively in pavement management. Life Cycle Assessment (LCA) is a method for considering environmental impacts over the life of an asset. LCA is more common in product development, but recently has been applied to transportation projects, though mostly in academic research. Both LCCA and LCA take a long-term view that is necessary for sustainability assessment. By integrating LCA and LCCA and adding metrics for social quality of life, transportation agencies could assess the sustainability of projects and plans.

The environmental, economic, and social implications of transportation infrastructure are not fully experienced until long after construction is completed. Over the course of its design life, infrastructure leads to considerable costs for annual maintenance and periodic repairs. It also costs money to monitor infrastructure for potential environmental or social impacts. Even at the end of its 20, 30, or 50-year design life, transportation infrastructure has considerable impacts like potential safety issues, demolition costs, and waste recycling or disposal. By considering the full costs of transportation projects over their design life, transportation agencies can prioritize capital and operating funds better or identify future funding gaps. The concept of life cycle engineering is depicted in Figure 5-25.

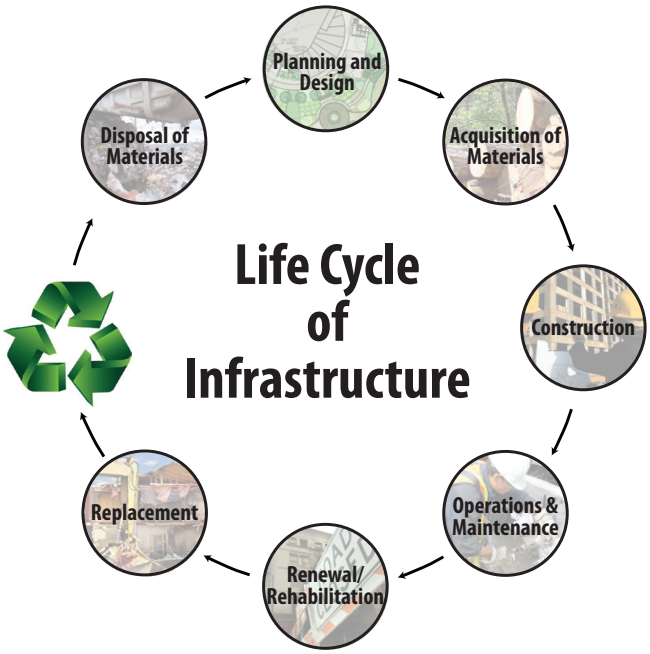

Figure 5-25. Life cycle of infrastructure

Life Cycle Cost Analysis (LCCA) or Life Cycle Costing (LCC) is a tool for evaluating the overall long-term economic efficiency of a system, product, or service. LCCA is valuable for comparing alternatives; however, it does not examine environmental or social impacts. LCCA used extensively for infrastructure asset management and by many state DOTs for pavement selection.

Life Cycle Assessment (LCA) is a method for assessing the total environmental impact of a system, product or service. It can be a valuable tool for the sustainability evaluation of competing alternatives (e.g., policies, plans, projects etc.). The tool was first developed for products. In the 1970s, economist Wasilly Leontief developed the Economic Input Output Life Cycle Analysis (EIO–

LCA) model. Researchers at the Green Design Institute at Carnegie Mellon University adapted the model in the mid-1990s into a user-friendly online tool to evaluate a commodity or service as well as its supply chain (http://www.eiolca.net/). The EIO-LCA model requires a lot of data, it provides an explicit opportunity to capture and include the environmental "externalities" of various decisions more accurately and thoroughly in transportation decision making.

How is LCCA used by State DOTs?

Life-cycle cost analysis (LCCA) has become a common practice in road construction and pavement design at the state level since the 1990s. Illinois DOT and Michigan DOT provide two examples of how LCCA is being effectively applied. Additional examples and guidance on conducting LCCA, including a costing tool, is provided by FHWA (http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm).

Illinois DOT

According to an IDOT bulletin from 1998, LCCA can improve money management by aiding selection of the material or project that will have the lowest costs over its entire usable life. IDOT's LCCA process evaluates alternatives based on the present worth of future capital, maintenance, and operations costs. It allows the agency to compare alternatives that may incur costs at different times during their lifecycle. It also incorporates the interest rate, which is an important consideration for large investments using brrowed funds. LCCA helps identify the best value for investment expenditures (i.e., the lowest long-term cost that satisfies the performance objective) [1].

Illinois DOT has used LCCA for a few different applications. The Materials Research Group uses it to analyze new and rehabbed pavement options. Chapters 53 and 54 of the 2002 Bureau of Design & Environmental Manual provides guidance on pavement LCCA [2]. The manual suggest s that LCCA be used as early as possible in the design process, and that it use the following characteristics:

- Analysis Period (sufficient to recognize long-term cost differences, typically 30-40 years for rehab)
- Economic Efficiency Indicator (Net Present Value preferred)
- Dollar Type (real/constant dollars and real discount rates)
- Discount rate (3%, same as for new pavement)
- Overhead costs
- Annual maintenance costs (generally very small, and often ignored)
- User costs (travel time delay, vehicle operating, and crash costs)
- Salvage value (based on remaining life of alternative at end of analysis period).

In 2003, IDOT also used LCCA to evaluate alternative Intelligent Transportation System (ITS) technologies. The agency planned to deploy ITS field devices in conjunction with several multi-million dollar construction projects, and was looking for the least cost option for communicating between the field devices and the District office. The alternatives analysis looked at the initial capital cost, operations and maintenance costs, and 15 year life cycle costs. The results showed that life cycle costs for the four options ranged from $43 million to $52.5 million. The analysis allowed staff to make a well-informed decision [3].

Michigan DOT

Michigan Department of Transportation (MDOT) has used LCCA in the pavement selection process since the mid-1980s.MDOT reviewed the effectiveness of the process in 2008. A research study used case studies to analyze how accurately MDOT projected actual costs over the pavement service life and whether they chose the lowest-cost pavement alternative. Ten highway sections in Michigan were grouped into four case studies. The researchers compared the estimated and actual accumulated construction costs and estimated versus actual maintenance schedules for activities like microsurfacing and joint repair. The study revealed two important trends: (1) MDOT's LCCA procedure correctly predicted the pavement type with lower initial construction cost and (2) actual costs were usually lower than estimated in the LCCA. To improve prediction of accumulated costs, the cost estimation module in MDOT's model could be refined to consider site-specific factors. The LCCA process helps MDOT's pavement engineers conduct a comprehensive assessment of long-term costs in order to allocate capital, operations and maintenance funds more optimally [4].

How has LCA been applied in transportation?

LCA has a range of applications in infrastructure decision making. It has been used to analyze the regional supply chain economic and environmental effects of shifting specified percentages of intercity freight carried by trucks to rail [5]. It has also been applied to compare alternative bridge deck designs from a sustainability perspective accounting for the total life-cycle costs including agency, user and environmental costs [6]; it has been applied to assess the impacts of using public road transportation to the use of private transportation (i.e. automobiles) [7]; and it has been applied in pavement design alternatives evaluation and materials selection [8]. Whitaker conducted life cycle assessments (LCAs) of energy use and greenhouse gas (GHG) emissions of existing mass transit systems in Denver, Colorado and Chennai, India [9]. The analysis focused on bus and electrified urban rail transit. Among other things, the analysis suggested that GHG emission factors of electric grids can be up to three times greater than for diesel fuel, comparatively disadvantaging electrified urban rail systems. Two researchers at the University of California, Berkeley developed a framework for life cycle assessment of passenger transportation. Using this framework, they analyzed the life cycle costs of several systems in the US including three different types of automobiles, typical urban buses, three sizes of aircraft, California's San Francisco Bay Area Rapid Transit (BART) and Caltrans, the Massachusetts's Boston Green Line, and the proposed California High Speed Rail. The analysis looked at the entire life cycle (design, raw materials extraction, manufacturing, construction, operation, maintenance, and end-of-life) of the vehicles, infrastructures, fuel production, and supply chains for each system. It quantified both energy inputs and GHG and criteria air pollutant outputs. The results can be used to inform funding prioritization for different modes [10,11].

How could LCA and LCCA address transportation sustainability?

In order to consider sustainability over the entire lifecycle of a transportation project or program, an integrated approach to LCA and LCCA could be applied. Flintsch proposes using LCA to evaluate transportation projects, programs, and strategic plans based on multiple sustainability criteria (engineering, economic, environmental, social) rather than just environmental indicators. LCA could also be enhanced by incorporating uncertainty, as is done with probabilistic LCCA. Flintsch suggests adapting the LCA framework from the International Organization for Standardization (ISO), as depicted in Figure

5-26 [12]. The key is to establish goals and inventory measures related to all aspects of sustainability. Yusoff and colleagues developed a similar framework for incorporating life cycle assessment into strategic transportation planning and project development activities. The framework covers both short-term and long-term environmental, economic, and social considerations. It integrates LCA with a systems analysis approach into a five-step process [13]:

Step 1: Identification of the system and the scope/objectives of analysis.
Step 2: Environmental and economic [and social] inventory.
Step 3: Environmental and economic [and social] impact assessment.
Step 4: Setup and evaluation of alternative scenarios.
Step 5: Action plan formulation and implementation, including maintenance plans.

Flintsch and Yusoff et al. seem to emphasize environmental and economic indicators. The United Nations Environment Programme (UNEP) broadens this framework by providing a framework and specific indicators for Social LCA of products, which could be adapted to transportation [14]. There are also tools like Health Impact Assessment (see Case Study) that could be integrated into an LCA process to assess broader social impacts. The integration of LCCA with Environmental LCA and Social LCA could help transportation agencies analyze the full range of sustainability impacts.

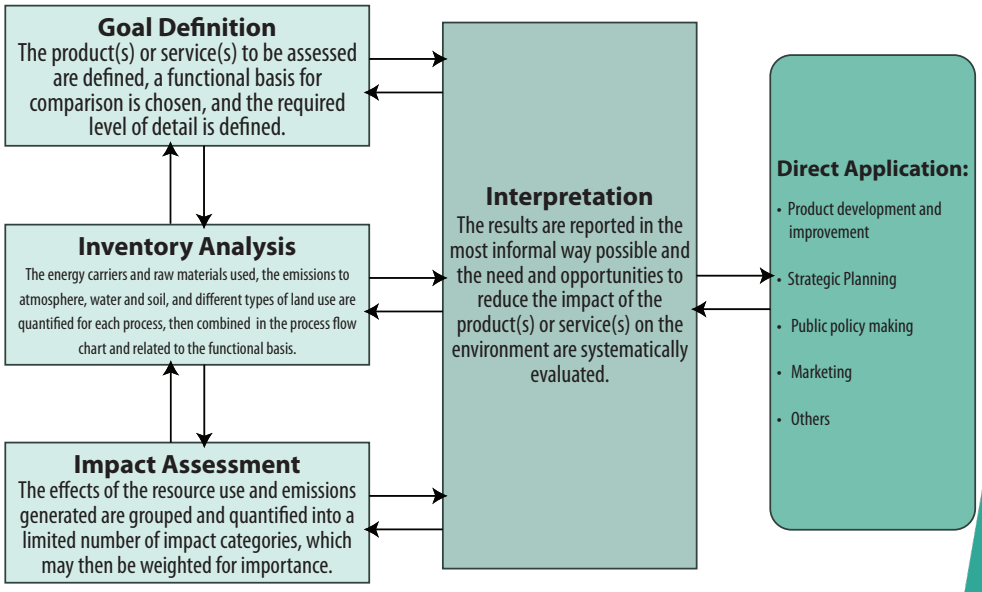

Figure 5-26. Framework and application of life-cycle assessment based on ISO guidelines. Source: Flintsch (2008)

Data Need:

Characterize (or quantify) the environmental, economic, and social impacts (benefits or costs) over the life of the facility, policy, et cetera. Consider direct and indirect impacts occurring during all stages.

Data Sources:

Data sources will vary though will likely require a mix of internally collected measures and public data sources.

Comments: **Data intensive**

Resources

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Chapter 6:

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