MONETARY VALUATION PER DOLLAR OF INVESTMENT IN DIFFERENT PERFORMANCE MEASURES

Requested by:

American Association of State Highway
and Transportation Officials (AASHTO)

Standing Committee on Planning

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DISCLAIMER

1. BACKGROUND

This chapter provides background on the report purpose and topics covered. It is organized into two parts: (1) Discussion of the motivation for this report, in terms of the problem of representing transportation-related performance measures in monetary terms, and (2) Discussion of the objectives and organization of this report.

1.1 The Measurement Problem

"Performance measures" are indicators of the outcomes of agency operations and programs, and are intended to measure their efficiency or effectiveness. Prior studies have documented the wide range of performance measures used by various transportation agencies, including measures of transportation access and mobility, safety, environment, economic development, energy resource use, quality of life and others. However, the units of measurement of these various performance measures often vary. Some are routinely measured in *monetary terms* (such as travel time and travel cost savings), while others are *quantified* in non-money terms (such as tons of pollution reduction). Still others are measured in *qualitative terms* (such as quality of life or satisfaction ratings). These different ways of measuring achievement make it difficult to assess program tradeoffs, and to use many important performance measures in "benefit-cost" or "return on investment" analyses.

Performance measures are being used by transportation agencies today for a variety of purposes, ranging from monitoring system performance to affecting budget allocations and project selection. Yet while many transportation agencies in the United States are using performance indicators to monitor transportation system performance, few have applied monetary values to the full range of performance benefits. In some performance categories—such as pavement preservation, bridge inspection, road safety, and congestion reduction — current practice often does include *quantitative* measures of performance. Efforts have also been made, in some cases, to *monetize* those quantitative performance metrics and to assign monetary values to project benefits aimed at improving this performance. Two good examples of this are the dollar value of cost-saving benefits assigned to pavement and bridge preservation investments, and the dollar valuation of travel time and vehicle operating cost savings associated with actions that reduce road congestion.

For projects focusing on mobility, safety or infrastructure preservation objectives, methods such as benefit-cost are now being used to measure and compare the value of benefits relative to investment costs. For other types of objectives -- such as minimizing environmental impacts, enhancing community quality of life and promoting economic development -- it is more difficult to know how much value is attained from the dollars invested. As a result, for many important categories of transportation system performance measurement in the United States, monetary measures are not used.

1.2 Report Objective and Organization

The primary objective of this report is to review the state of practice of assigning monetary values to performance measures that are not normally measured in money terms, and provide information on the most promising tools and practices for monetizing benefits. The experience in monetizing performance measures for those organizations that have done so and the organizational requirements associated with successfully doing so are also examined. While not all measures of concern to decision makers can be reduced to a dollar dimension, this report does provide a basis for organizations to better ascertain the extent to which such monetization is possible.

The research methodology for this study consisted of five steps:

- ***Identify the state of practice***, in terms of the range of benefit and performance measurement topics of interest to state and regional transportation agencies (discussed in Chapter 2),
- ***Summarize general methodology***, in terms of approaches used to represent performance measures in monetary terms (discussed in Chapter 3),
- ***Present valuation for specific impacts***, focusing on non-traditional transportation-related performance measures (discussed in Chapter 4),
- ***Present case studies***, illustrating how different types of agencies, including non-transportation agencies, use these methods (discussed in Chapter 5), and
- ***Develop guidance*** for transportation agencies on useful approaches to improve performance measurement (discussed in Chapter 6).

2. STATE OF PRACTICE

This chapter provides an overview of the current practice in using performance measures by various state and regional transportation agencies around the US. It is organized into four sections: (1) classification of the range of different types of performance measures, (2) discussion of the ways in which these various performance measures are measured in terms of qualitative and quantitative data, (3) assessment of the degree to which the quantitative performance indicators are or can be represented in monetary terms, and (4) discussion of the issues confronting transportation agencies wanting to use monetary measures in performance measurement.

2.1 Use of Performance Measurement

Use by State Transportation Departments. Many state transportation agencies have been using performance measures for internal management purposes and external accountability reasons for many years. Minnesota and Florida were two of the first states to use performance measures in the management of their transportation agencies and in the development of performance-oriented statewide transportation plans and programs. Other state DOTs have also been early adopters of transportation performance measures, including those in Arizona, Kentucky, Maryland, Missouri, Oregon, Tennessee, Virginia and Washington.

Each of state DOTs cited above issue annual reports which include indicators of agency or transportation system performance. Most focus on measuring achievement of agency goals relating to service delivery (e.g., levels of maintenance and snow plowing achieved) and transportation system performance (e.g., congestion levels and the state's safety record). A smaller number of states also include indicators of other environmental and economic factors that are affected as a consequence of their transportation-related programs and policies. Illustrative examples of the different performance measures used by various states are shown in Appendix A. Links to state DOT performance indicator reports can also be found at www.wsdot.wa.gov/accountability/library.

Use by Regional Agencies. A small but growing number of metropolitan planning agencies (MPOs) have incorporated performance measures into their planning programs. Some of the more prominent MPOs that have done so include: the Atlanta Regional Commission (ARC), the Delaware Valley Regional Planning Commission (DVRPC), the Metropolitan Transportation Commission (MTC--San Francisco Bay Area), the North Central Texas Council of Governments (NCTCOG) and the Puget Sound Regional Council (PSRC).

While regional agencies include transportation system performance measures similar in concept to those used by state DOTs, such as congestion, mobility, and transit ridership, they are more likely than state DOTs to include measures of land use, economic development and environmental quality that are indirectly affected by transportation system changes. This is not surprising given that MPOs have much broader mandates to their local communities and often have no or very limited roles in operating transportation systems. Some MPOs also have explicitly designated roles in air quality monitoring and/or economic development support services. Examples of the range of performance measures used by regional agencies are also shown in Appendix A.

Range of Differences. Not surprisingly, the different types of performance measures used by state and regional transportation agencies often vary by state and region. These differences reflect both the type of problems a state's transportation system faces and the priorities established by a state legislature or MPO executive committee. The performance measures also differ in terms of their uses, which range from operations monitoring and plan/program goal achievement to project prioritization and decision-making.

NCHRP Report 446 surveyed state DOTs to determine how many were using a performance-based transportation planning process and the indicators used to measure performance and impacts.[1] This current report uses the classification of performance measures from *NCHRP 446*, supplemented by an additional web search of state DOT and MPO planning web sites and a conference call with a panel of state DOT officials. Based on this input, the different types of performance measures are classified in terms of: (a) *direct effects* on transportation system performance, (b) *indirect effects* on people and their environment, and (c) *other societal considerations* reflecting progress toward social goals.

Appendix A illustrates the wide range of performance measures being used by various state and regional agencies. Note that it focuses primarily on the indirect and societal performance indicators being used by various transportation agencies. It does not focus on direct indicators of transportation system operations (vehicle speeds/times, volumes and distances/costs), since these measures are already well developed, widely used and can be monetized with generally-accepted monetary valuation methods.

2.2 Classes of Performance Measurement

Classification. The oft-used concept of "performance measures" can actually encompass a wide range of impact and benefits, which can be classified as follows:

Direct Effects – Indicators of Transportation System Performance

- Accessibility
- Mobility
- Operations Efficiency (Average Travel Time and Distance)
- Operations Reliability
- Freight transportation movement
- Customer satisfaction
- Safety
- System preservation

Indirect Effects – Indicators of Impact on People and their Environment

- Economic development
- Environmental quality (Air, Water, Land)
- Health
- Quality of life
- Security

Other Societal Considerations – Progress Toward Goals

- Energy efficiency and Resource Conservation
- Environmental justice (equity)
- Sustainability (financial and physical)

Performance Measurement. The Table 2.1 shows the fifteen "classes" of impact or benefit measures, along with examples of relevant indicators and the different types of agency applications or uses for them.

For each performance measurement class, the second column provides examples of the indicators often found in practice. These indicators include both direct measurement of system operations and characteristics and surrogate measures that can be used when direct measurement of the progress or performance of the specific goal or topic is not possible.

The third column shows the applications or possible uses of the information obtained from the indicators for each impact class, as revealed from a review of current practice. As shown, the applications most often found in practice include: (1) project prioritization, (2) network monitoring, (3) plan/program goal achievement, (4) management benchmarking against prior performance and peers, and (5) public information.

Table 2.1: Classes of Benefit and Indicators of Performance

Impact Class	Indicators	Categories of Application
Accessibility	**Direct –** Modal options, Travel times to key destinations, # of roads and bridges with use limitations, households or jobs within given distance (or time) **Indirect -** Accessibility index	• Project prioritization • Network monitoring • Plan/program achievement • Management benchmarking • Public relations
Mobility	**Direct -** Travel times, Delay, Vehicle- , person- and ton-miles traveled, Mode split, Availability of modes **Indirect -** Mobility index	• Project prioritization • Network monitoring • Plan/program achievement • Management benchmarking • Public relations
Safety And Health	**Direct -** Crash/fatality data, Vehicle/pedestrian counts (for exposure data), Special counts (e.g., seatbelt use) **Indirect -** Societal costs of crashes, Hazard or crash index, Customer perceptions	• Project prioritization • Network monitoring • Plan/program achievement • Management benchmarking • Public relations
Operations Efficiency/ & Reliability	**Direct -** Travel time (by mode), Volumes, vehicle occupancy, Travel costs, Vehicle/ passenger miles traveled, Speeds, Delay **Indirect -** Travel time index, Congestion index, Reliability index	• Project prioritization • Network monitoring • Plan/program achievement • Management benchmarking • Public relations
System Preservation	**Direct -** Condition ratings, Infrastructure age, Remaining service life **Indirect -** Infrastructure condition index	• Project prioritization • Network monitoring • Plan/program achievement • Management benchmarking
Customer Satisfaction	**Direct -** Customer survey/opinion ratings **Indirect -** Voter approval of referenda	• Network monitoring • Plan/program achievement • Management benchmarking
Economic Development	**Direct -** Economic costs of delay and travel time, Economic costs of crashes, Jobs created **Indirect -** Property tax revenues	• Project prioritization • Network monitoring • Plan/program achievement • Public relations
Energy & Resource Conservation	**Direct -** Energy consumed **Indirect -** Sprawl index	• Network monitoring • Plan/program achievement • Public relations
Environmental Justice (EJ)	**Direct -** Transport costs and Relative travel times and accessibility to activity centers, by societal (income/age/race/ cultural) groups **Indirect -** Relative welfare of societal groups	• Network monitoring • Plan/program achievement
Environmental Quality	**Direct -** Air quality, Water quality, Noise levels, Wetlands affected **Indirect -** Fuel consumed, Health of the population, Sprawl	• Project prioritization • Plan/program achievement • Management benchmarking • Public relations

Table 2.1 (cont.): Classes of Benefit and Indicators of Performance

Impact Class	Indicators	Categories of Application
Freight Transportation	**Direct** - Travel and transfer times, Delay, Costs, Vehicle- or ton-miles, Speed **Indirect** - Economic productivity of freight sectors	• Project prioritization • Plan/program achievement • Management benchmarking • Public relations
Quality Of Life	**Direct –** social, cultural and satisfaction survey/opinion ratings **Indirect** - Sprawl index, Composite index	• Plan/program achievement • Public relations
Security	**Direct** - Number of security incidents successfully or unsuccessfully handled **Indirect** - Insurance costs	• Plan/program achievement • Management benchmarking • Public relations
Sustainability	**Direct** - None **Indirect** - Resources consumed, Sprawl index, Environmental quality measures, Societal costs	• Plan/program achievement • Public relations

Source: scan of the state of practice by the authors of this report

The final column of Table 2.1 is important in that how the information is to be used in an organization influences the degree of precision that is needed and the methods that may be appropriate to collect the data. For example, if reporting on the safety of the road system to the general public is important, then that can be accomplished by simply using overall fatality and crash numbers. However, if there is a further desire for management benchmarking or any other purpose aimed at reducing the number of crashes, then the data would most likely have to be further refined to include crashes by type, contributing environmental factors, and driver characteristics.

The relationship between types of desired uses and corresponding measurements methods can have many facets, and transportation agencies can benefit from further guidance on how precise and detailed data has to be before it can be usefully employed in an array of performance measures. While this report is not intended to be that guidebook, it does demonstrate the nature of differences in methods and precision associated with various performance elements. That is a necessary first step in a longer term process towards improving our understanding of the limitations and potential uses of performance measurement methods.

2.3 Ability to Monetize ($) Indicators

Three Categories of Performance Measure Monetization. The preceding Table 2.1 is the principal starting point for identifying the performance measurement categories where monetization can be most feasible and appropriate. Examining the "types of measurement" column in this table suggests that some of the performance measure categories could be amenable to monetized valuation (such as the cost of congestion or societal costs of crashes), while others are more often difficult to monetize or even quantify. Examples of the latter include quality of life, environmental quality, security, and sustainability. In these "difficult" categories, many of the measures have been considered in a broad way with a goal of simply determining whether an initiative enhances quality of life, lowers it, or has no impact. Providing guidance on how some of these "difficult" measures have been monetized elsewhere could provide very useful information to state DOTs for use in assessing the relative benefits of alternative investment strategies.

A third type of monetization challenge could include those that are controversial to monetize. The categories of "Safety" and "Environmental Quality" fall into this group because both affect mortality and health. There is still significant debate about exactly how to best value health and saving a life. On the other hand, it is also true that even when there is a lack consensus on exact valuation, the scale and magnitude of benefits can sometimes be large enough to clearly dwarf other effects. This can be true, for example, of initiatives that will reduce emissions of air pollutants. As there is growing interest in these issues, the monetization of health-related environmental and safety impacts is discussed further in Chapter 4 of this report.

Understanding of Performance Measures. The primary use of performance measurement is to provide information to those responsible for system operations (or of providing funds to support transportation investment) on the status of system performance and on the progress being made. One of the challenges of performance-based planning is thus the need to provide this information in ways that are most useful for both agency decision makers and external audiences. A good illustration of this challenge is found in the reporting of system safety performance.

Most states report the number of fatalities and injuries that occur on their road network. These numbers certainly convey the magnitude and severity of the road safety challenge facing the country to transportation and safety professionals. However, to non-transportation professionals, such data are often difficult to interpret. And for local officials responsible for developing a regional investment program, it is often not clear how safety benefits compare to other challenges facing a metropolitan area. One way of providing such a comparison is to develop a common metric among the different investment objectives, with monetary valuation being one possible method.

In the state of Washington, for example, the development of the latest version of the state transportation plan, and now the state's strategic highway safety plan, received the personal attention of the state's secretary of transportation when it was estimated that the cost to society of the crashes on the state's roads exceeded $5.3 billion annually. This figure was much greater than the estimated annual congestion cost on the state's road system. Similarly, in Atlanta, a study found that the 2002 estimated societal cost of crashes was 1.5 times the corresponding cost of congestion. The monetization of the safety challenge facing the Atlanta region, especially when compared to the annual cost of congestion, has caused additional focus to be placed on transportation safety by planners and decision makers.

Assessment of the Monetization of Performance Measures. Based on a review of the literature and an assessment of the current state-of-the practice, a determination of which of the previously defined performance measure categories are conducive to some form of monetization is presented in Table 2.2. The comments on monetization measurement reflect the range in uncertainty in being able to translate the various impacts and outcomes into monetary terms.

Table 2.2: Assessment of Monetization Potential of Categories

Impact Class	Comments on How These Impacts or Benefits are Monetized
Accessibility	The monetary value for accessibility can be some form of the economic value of the activity that is occurring on the land enabled by transportation investment. Or the value of the travel time associated with accessing a particular activity might be a surrogate for the monetary benefit associated with such a trip (for example, such an approach is used for valuing recreational trips to major parks).
Mobility	The value of mobility improvements is commonly measured as the value of time and cost savings resulting from traffic congestion reduction or transit service improvement. For freight, there can be an economic measure of improved productivity for the freight sector.
Safety	Monetary measures can be developed for safety performance, based on the societal cost of vehicular crashes (from NHTSA) and the cost of injuries and death (by FHWA and other agencies).
Operations Efficiency/Reliability	Researchers have worked to develop a value of time measure for reduced variance in average travel time.
System Preservation	This is represented as determining the economic loss of not replacing old infrastructure at the economically optimal time.
Customer Satisfaction	It is not clear how to monetize customer satisfaction, except via a survey of stated preferences.
Economic Development	The economic value of transportation investment can be estimated through the use of economic methods and models.
Energy & Resource Conservation	The value of reduced consumption of non-renewable resources is measurable as the cost savings to society and consumers.
Environmental Justice (EJ)	An economic value could be placed on the enhancement of mobility for EJ communities resulting from transportation investments, although that is only one aspect of a more complex set of concerns and it it does not fully capture the value of achieving social equity goals.
Environmental Quality	The traditional approach is to assign monetary values to the reduction in health risks associated with transportation improvements.
Freight Transportation	Similar to mobility, one can assign an economic value to the time savings associated with transportation improvements.
Quality Of Life	It is not clear how to measure quality of life monetarily except via a survey of stated preferences.
Security	It is not clear how to measure security enhancement from a monetary perspective except perhaps via a survey of stated preferences
Sustainability	This is analogous to environmental quality, but is much broader and thus more difficult to assign a monetary value.

To date, agencies have generally had the greatest success in monetizing system-level operations and maintenance-related measures (such as pavement quality, bridge deficiency, and safety records), and capacity-related measures (such as volume to capacity ratio, or level of service rating). For example, one can examine the monetary trade-offs involved in maintaining a road or bridge today rather than allowing the asset to deteriorate (this is, in fact, the basis of current efforts at asset management). Well-established data collection and analysis techniques have reinforced the use of these and other similar measures as a tool for assessing performance and managing organizational direction.

Among the impact or benefit classes listed in the table, the transportation profession is most likely to be already familiar with the monetization of mobility, operations efficiency and freight transportation (using measures based on the value of time and of variability of travel time) and system preservation (based on measures of the economic cost or valuation of not replacing assets). Consequently, these categories are given only a cursory review in the remainder of this report. Special attention is given to safety (value of life, injuries and property damage), economic development (a variety of measures), environmental quality, and energy conservation. These performance categories are the focus of the Chapter 3 assessment of monetization methods and the Chapter 4 case studies.

It is important to note that these various impact or benefit categories are being increasingly viewed as strategic areas of concern by transportation agencies at state and national levels. For example, the recently implemented Strategic Highway Research Program-II is pursuing ways to integrate more fully environmental and economic objectives into transportation planning and project development.[2] A number of other countries and international organizations are also striving to develop quantifiable indicators of progress along this path.

Other performance measurement categories are presented only briefly and are not the subject of rigorous inquiry primarily because it is not clear how monetization approaches could be used. These categories include customer satisfaction, quality of life, security and sustainability (in a general sense). Although attempts have been made to quantify such measures, the research team has not found any examples of reliable or widely accepted methods for translating these system performance characteristics or corresponding benefits into monetary terms.

3. MONETIZATION TECHNIQUES

This chapter provides an assessment of the current literature on approaches to monetize transportation-related performance measures. It focuses specifically on alternative techniques for assigning dollar values that are applicable across a wide range of benefit and impact classes. It is organized into four parts: (1) a discussion of the consequences of making choices among methods and assumptions, (2) a classification of the approaches and methods available, and (3) federal guidance on monetization techniques.

3.1 Implications of Methods and Assumptions

Need for Full Coverage. As inputs to economic evaluation,[3] the monetary value of performance measures have the power to affect the benefits assigned to various alternatives or system performance levels. A fundamental challenge of performance measurement, then, is to provide the most reliable and unbiased representation of impacts, in a format that allows for different dimensions of performance to be compared and combined. There is always a danger of criticism that the selection of specific methods for quantifying and monetizing impacts can shift findings on the relative benefit or harm that may result from any given program or project.

It is particularly important to note that decision-making can be biased just by the tendency to focus on easy-to-measure impacts.[4] In the past, travel time delay and crash losses have been monetized. It is only in recent years that economists have begun also to monetize environmental and social impacts, facilitating decisions involving trade-offs between market and non-market goods. By including monetary valuation of non-market factors (i.e., factors that do not have intrinsic prices in the marketplace), it becomes possible for these factors to be incorporated into economic analysis…they will not be overlooked or undervalued. Public agencies may then use such data when deciding how much to spend to achieve certain goals. Yet at this time, transportation agencies are not in a position to have reliable monetization of all relevant performance and impact factors, so there is a remaining need (beyond this report) for further guidance on the nature of these potential biases, and on business processes that may be employed to mitigate their effect on decision-making.

Concept of Information Transfer. Transportation is far from being the only professional field interested in performance measurement, and transportation agencies are not the only public agencies interested in assessing broader impacts on public safety, environment, energy and economic development. In fact, other professional fields have been far ahead of transportation in considering a wide range of performance measures in their decision making processes. There is substantial potential for an "information transfer" of analysis methods that are used in other fields.

3.2 Major Classes of Measurement Techniques

The literature review conducted for this study covered methods used in a wide variety of fields for monetizing performance measures. Particular attention was given to the technical guidance and standards adopted for the topics of environmental quality, health care and economic development. This section starts out with a broad review of the various techniques and approaches used in other fields for applying monetary conversions to various non-money performance indicators. It also notes the strengths and weaknesses associated with the various techniques or approaches.

The monetization of benefits and costs can be accomplished using several different techniques, each of which is unique and can be applied under specific circumstances. The methods to quantify and monetize non-market impacts can usually be found in one of the following approaches:[5]

1) ***Damage Costs.*** This reflects the total estimated amount of economic losses produced by an impact. For example, the damage costs of traffic crashes would include vehicle damages, costs of providing medical and emergency services, lost productivity when people are disabled or killed, plus any non-market costs, such as pain, suffering and grief. Since this often involves different types of costs, measuring them requires different approaches and techniques.

2) ***Control or Prevention Costs***. A cost can be estimated based on what it would cost to prevent, control or mitigate an incident after it occurred. For example, if a manufacturing or power plant is required to spend $1,000 per ton to reduce the level of air pollution, we can infer that society considers the pollutant emission to impose costs at least that high if the levels were not lowered. If both damage costs and control costs can be calculated, the lower of the two is generally used for analysis on the assumption that a rational economic actor would choose prevention if it is cheaper, but would accept the damages if prevention had a higher cost.

3) ***Hedonic Methods (also called Revealed Preference***). Hedonic pricing infers values for non-market goods from their effect on market prices, property values and wages. For example, if houses on streets with heavy traffic are valued lower than otherwise comparable houses on low traffic streets, the cost of traffic (conversely, the value of a neighborhood being quiet, clean, safe, and private) can be estimated. If employees who face a certain discomfort or risk are paid higher than otherwise comparable employees who do not, the costs of that discomfort or risk can be estimated.

4) ***Contingent Valuation (also called Stated Preference).*** Contingent valuation infers costs by surveying a representative sample of individuals as to how much they value a particular non-market good. For example, residents may be asked how much they would be willing to pay for a certain improvement in air quality, or an acceptable minimal compensation for the loss of a recreational site. While this technique can provide valuation for a very wide range of factors, there is evidence that survey respondents frequently over-estimate the extent to which they are willing to actually pay for and use new transportation services or improvements. For that reason, any such surveys need to be very carefully structured and interpreted to obtain accurate results.

5) ***Compensation Rates.*** Legal judgments and other compensation rates for damages can be used as a reference for assessing non-market costs. For example, if crash victims are compensated at a certain level, this amount can be considered as a representative estimate of the cost of damages, pain and discomfort. However, many damages are never compensated, and it would be poor public policy to compensate all such damages fully, since this may encourage some people (those who put a relatively low value on their injuries) to take excessive risks or even to cause a crash in order to receive compensation. As a result, compensation costs tend to be lower than total damage costs when used in benefits estimation.

6) ***Shadow Prices.*** This method uses visitors' actual travel-related costs incurred (monetary expenses and time cost) as a way to measure the "consumer surplus" provided by making a trip to visit a recreation site such as a park or other public lands. "Shadow prices" may also be used to assign costs to specific types of emissions and to withdrawals of resources due to transportation.[6]

Verhoef (1994) combines these various monetization methods into three general classes, each with its own advantages and disadvantages.[7]

- *Shortcut Approaches* – Techniques such as "Control or Prevention Costs" are considered shortcut approaches. They run the danger of underestimating the true benefits of an improvement because they adopt an available measure of cost impact to represent the full societal value of a broader benefit. For example, the value of air quality improvements resulting from transportation policies can be valued as the avoided cost of implementing pollution control measures that would otherwise be required by federal air quality regulations. However, the true societal "willingness to pay" for these environmental benefits may be greater than the avoided cost of compliance with regulations. In addition, abatement costs associated with other environmental conditions may still remain.

- *Non-Behavioral Valuation Approaches* - Techniques such as "Damage Costs" and "Compensation Rates" are considered non-behavioral because they aim at estimating the monetary value of unpriced impacts. The former develops a valuation based on cost of physical damage that is incurred or avoided, while the latter develops valuation based on jury judgments of real or perceived costs incurred. For example, air quality improvement can be valued as the reduction in building repair costs that would otherwise result from continuation of current air pollution impacts on outside walls. Similarly, safety benefits can be valued as the reduction in medical care costs that would otherwise occur from continuation of dangerous intersections and road curves. By themselves, these methods represent low-side measures of true value, particularly because they cannot infer any valuation of benefit for non-users of the transportation facilities. However, they receive much use in practice because the results appear to be "harder" (i.e., more directly observable and easier to document) than those obtained with other techniques.

Behavioral Valuation Approaches – Techniques such as "Revealed Preference," "Shadow Prices" and "Stated Preference" are considered behavioral valuation approaches because they observe consumer behavior or choices made in response to a change in conditions. In each case, surrogate markets are sought in which observable environmental attributes accompany goods or factors being traded. "Hedonic prices" are inferred based on a statistical analysis of revealed preferences from observed situations. "Shadow prices" are inferred from the costs that households are willing to pay for particular outcomes. If actual markets do not exist, then "contingent valuation" methods provide survey respondents with simulated markets where they can express their hypothetical valuations of improvements or degradation of environmental quality. All of these techniques have the advantage that they seek to measure the full user value of various transportation or environmental goods. However, they all have the disadvantage that their results are considered "soft" because they rely on statistical inferences rather than observed costs or damages, and they often also involve hypothetical rather than real behavior.

3.3 Federal Guidance on Monetization

The federal government has released important guidance on monetization in recent years. Two, in particular, seem most relevant to this study. In 2003, the Office of Management and Budget (OMB Circular A-4) released guidance on regulatory analysis in which it addressed estimation of costs and benefits and even provided some guidance on methodologies.[8] While this Circular was developed as an update to an earlier "best practices" document, by itself, it offers broad practical advice on the application of monetization and choice of specific techniques.

In December 2004, the General Accounting Office (GAO) convened a workshop on economic performance measures. In describing the workshop objectives, GAO's

Managing Director of Applied Research and Methods and its Chief Economist in that group linked the ability to economically measure the performance of federal programs with the twin goals of "ensuring that the federal government's programs and priorities meet current and future challenges" and deficit reduction.

Key issues drawn from these discussions of performance measure monetization are discussed below. Examples are provided for each. While these examples are largely from environmental impact applications, their lessons can apply equally to all aspects of transportation performance impact.

- ***Positive vs. Negative Effects*** **–** Improvements in environmental, energy or economic development conditions can be viewed in terms of "positive benefit," or in terms of the "avoided cost" of losses that would otherwise be incurred. In some cases, total "benefits" will reflect a mix of realized benefits and avoided costs.

  For example, water quality improvements in a local river will both reduce the costs of remediation efforts and also produce benefits in terms of recreational opportunities. Another example is air quality for areas that are not in attainment with national standards for an air pollutant. In those cases, the benefits of a reduction in that air pollutant may be proxied using the average cost of emissions reduction for that pollutant. For pollutants where emissions credits trading markets exist, such as for sulfur oxides (SOx) and nitrous oxides (NOx), the market value of emissions trading credits ($/lb) simultaneously represents realized benefits (for firms that can sell excess credits) and avoided costs (for firms that reduced emissions rather than bought credits).

  The 2003 OMB Circular noted the need to include both positive and negative elements in the context of health benefit valuation, noting that: "…it is important to consider two components: (1) the private demand for prevention of the nonfatal health effect, to be represented by the preferences of the target population at risk; and (2) the net financial externalities associated with poor health such as net changes in public medical costs and any net changes in economic production that are not experienced by the target population" (p.29)[9]

- ***Active vs. Passive Impacts*** -- Benefits can also be classified into what are termed "use" and "non-use" values. According to Stavins (2004), "use value" represents the "direct benefits…people receive through protection of their health or through use of a natural resource".[10] "Non-use" value is the "passive…value from environmental quality, particularly in the ecological domain." Stavins also notes that non-use value derives from a "bequest value, the preservation of a good for later generations and "existence" value, which derives from "simply knowing [a thing] exists." Others have identified a third category of non-use value termed "option value," which is a type of "insurance premium that prospective users, unsure of their future use of a good, would be willing to pay to retain the option of future use."[11]

- ***Timing and Sorting of Impacts* –** The 2003 OMB Circular suggests that users carefully track differences in the timing of various costs and impacts, and also track impacts that can be monetized separately from those that cannot be monetized at this time. It includes the following general guidance:

  - "include separate schedules for the monetized benefits and costs that show the type and timing of benefits and costs, and express the estimates in this table in constant, undiscounted dollars…
  - list the benefits and costs you can quantify, but cannot monetize, including their timing
  - describe the benefits and costs you cannot quantify; and
  - identify or cross-reference the data or studies on which you base the benefit and cost estimates." [12]

- ***Flexibility* –** A separate report by EPA's Science Advisory Board developed guidance for monetization of environmental performance measures and noted that "Different approaches [including economic methods, social/ psychological assessments, and ecological approaches] could be used at different stages of the valuation process." In addition, the report goes on to note that, "the suite of methods used could vary with the specific policy context, due to differences across context in: a) information needs, b) the underlying sources of value being captured; c) data availability; and d) methodological limitations." (p.27) [13]

- ***Social Policy* –** The monetization of performance measures naturally raises issues of whether it is appropriate to vary monetary values among locations. For instance, value of time is often developed on the basis of average wage rates, which can vary significantly among areas. In addition, the present value of lifetime earning power can also vary by current age of the individual. Yet the guidance across different fields is to avoid making these distinctions, which would imply in the first case that saving travel time has less value in a poor location than in a rich one, and in the second case that saving a life has less value where older people live. In both cases, making these distinctions is socially unacceptable. EPA's Science Advisory Board (previously cited) emphasizes this same point in noting that the value of a statistical life should *not* be adjusted for age.

4. VALUE OF SPECIFIC IMPACTS

While the previous chapter described general approaches to monetization, this chapter describes specific factors and analysis methods used for assigning dollar values to transportation project impacts. It focuses on impacts that are less familiar to transportation professionals, but are being increasingly monetized: (1) valuation of environmental impacts, (2) valuation of safety impacts, (3) valuation of access and mobility impacts and (4) valuation of economic development impacts.

4.1 Monetizing Environmental Impacts

Environmental Impact Policies. Environmental impacts are most often measured in terms of tons of pollution emitted in a given study area. For transportation analysis, this typically means air pollution emissions, although it can also encompass water pollution emissions or land pollution (such as loss of wetlands or loss of usable land). When monetized, environmental impacts are usually calculated on the basis of a "dollars per ton" valuation of a given pollutant.

There is substantial precedent for measuring environmental effects as a transportation-driven impact. In 2003, the US DOT identified the agency's strategic outcomes with respect to the human and natural environment. They included: enhancing sustainability and livability of communities, reducing adverse effects and improving the viability of ecosystems and the natural environment, and reducing the amount of pollution from transportation sources.[14] US DOT's *Performance Report* has also tracked greenhouse gas emissions from transportation sources.[15]

The Federal Highway Administration (FHWA) has also stated its environmental goals of seeking to maintain the ratio of wetlands replaced for every acre affected by Federal-aid highway projects, increasing the percent of DOT facilities characterized as "No Further Remedial Action" under the Superfund Amendments and Reauthorization Act, reducing the average number of area transportation air quality emissions conformity lapses, reducing the tons of hazardous liquid materials spilled per million ton-miles shipped by pipelines, and reducing the number of people within the U.S. who are exposed to significant aircraft noise levels.[16] A potential performance measure could be associated with each of these goals.

FHWA is now pursuing broader efforts such as integrated planning and ecosystem viability. Likewise, FHWA's efforts on reducing transportation pollution now extend to supporting community livability and smart growth, as well as the more discrete mobile source emissions, oil and pipeline spills, and aircraft noise exposure.

For state DOTs, the focus historically has been on air pollution. However, the question of which air pollution benefits to monetize can be difficult. It is not possible to link reduction in local emissions of pollutants associated with global environmental problems, such as climate change or ozone depletion, to actual changes in local conditions or climate. At the same time, even if the benefits cannot be monetized, reductions in these emissions might be important for internal or external environmental goals.

For local air pollution issues, a state can focus the monetization of emissions reductions on the six "criteria pollutants" for which the state (or sub-state area) is out of attainment of the U.S. Environmental Protection Agency's National Ambient Air Quality Standards (NAAQS). The six criteria pollutants are: (1) carbon monoxide, (2) lead, (3) nitrogen dioxide, (4) particulate matter, (5) ozone, and (6) sulfur oxides.[17]

Two sets of attainment standards are followed: a primary standard, which aims to protect public health; and secondary standards, which "set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings."[18] In practice, primary and secondary standards are identical for all criteria pollutants except sulfur dioxide (See Table 4-1).

Table 4-1. National Ambient Air Quality Standards for Criteria Pollutants[19]

Pollutant	Primary Standards	Averaging Times	Secondary Standards
Carbon Monoxide	9 ppm (10 mg/m^3) 35 ppm (40 mg/m^3)	8-hour[1] 1-hour[1]	None None
Lead	1.5 µg/m^3	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	50 µg/m^3 150 ug/m^3	Annual[2] (Arith. Mean) 24-hour[1]	Same as Primary
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3 65 ug/m^3	Annual[3] (Arith. Mean) 24-hour[4]	Same as Primary
Ozone	0.08 ppm 0.12 ppm	8-hour[5] 1-hour[6] (Applies only in limited areas)	Same as Primary Same as Primary
Sulfur Oxides	0.03 ppm 0.14 ppm -------	Annual (Arith. Mean) 24-hour[1] 3-hour[1]	------- ------- 0.5 ppm (1300 ug/m^3)

Source: US Environmental Protection Agency, see http://www.epa.gov/air/criteria.html#1#1

Valuing Emissions Damage. The level of monetary benefits associated with transportation emissions reduction is highly sensitive to context, including existing levels of pollution in the affected areas; density of population in an area; time of day (peak vs. non-peak); season, and other factors. As such, general values of monetary benefits should only be used to get a broad sense of the value of emissions reductions and in cases where better information is not available.

Table 4-2 presents FHWA's national average air pollution costs per mile driven for four types of vehicles, with a air pollution by trucks estimated to be 3.9 cents per mile. Table 4-3 shows FHWA's estimates of the marginal costs of highway use by trucks, including costs associated with air pollution, as well as noise, traffic accidents and congestion. It places the cost of air pollution by trucks at 3.8 to 4.5 cents per mile, depending on urban or rural settings. Table 4-4 shows alternative estimates of average private and external costs of freight movements, derived from data in Forkenbrock, 2001.[20] That study places the total cost of air pollution plus greenhouse gas emissions by trucks in the range of 4 cents per mile. Altogether, these studies indicate a consensus estimate of 3.8 to 4.5 cents/mile.

Table 4-2. FHWA 1997 Air Pollution Cost Estimates (1990 dollars)

Vehicle Class	Total ($1990 Million)	Cents per Mile
Automobiles	$20,343	1.1
Pickups/Vans	$11,324	2.6
Gasoline Vehicles >8,500 lbs	$ 1,699	3.0
Diesel Vehicles >8,500 lbs	$ 6,743	3.9

Original Source: FHWA, 1997 Federal Highway Cost Allocation Study Final Report Addendum, Federal Highway Administration, USDOT (www.ota.fhwa.dot.gov/hcas/final), 2000, Table 12.

Table 4-3. Marginal Costs of Highway Use by Trucks (Cents per Mile, 1997)

Cents per Mile						
Vehicle Class/ Highway Class	**Pavement**	**Congestion**	**Crash**	**Air Pollution**	**Noise**	**Total**
Urban						
40 kip 4-axle S.U. Truck/Urban Interstate	3.1	24.48	0.86	4.49	1.5	34.43
60 kip 4-axle S.U. Truck/Urban Interstate	18.1	32.64	0.86	4.49	1.68	57.77
60 kip 5-axle Comb/Urban Interstate	10.5	18.39	1.15	4.49	2.75	37.28
80 kip 5-axle Comb/Urban Interstate	40.9	20.06	1.15	4.49	3.04	69.64
Rural						
40 kip 4-axle S.U. Truck/Rural Interstate	1	2.45	0.47	3.85	0.09	7.86
60 kip 4-axle S.U. Truck/Rural Interstate	5.6	3.27	0.47	3.85	0.11	13.3
60 kip 5-axle Comb/Rural Interstate	3.3	1.88	0.88	3.85	0.17	10.08
80 kip 5-axle Comb/Rural Interstate	12.7	2.23	0.88	3.85	0.19	19.85
NOTE: S.U. = Single Unit, Comb. = Combination; Air pollution costs are averages of costs of travel on all rural and urban highway classes, not just Interstate. Available data do not allow differences in air pollution costs for heavy truck classes to be distinguished.						

Source: Reproduced in part from Addendum to the 1997 Federal Highway Cost Allocation Study Final Report; U.S. Department of Transportation Federal Highway Administration, May 2000, Table 13.

Table 4-4. Average Private and External Costs of Freight (Cents per ton-mile, 1994)

	Truckload Shipment	Mixed Freight Truck	Inter-Modal Truck	Double-Stack Truck
Private Vehicle & Driver Cost	8.42	1.20	2.68	1.06
External Cost	**0.86**	**0.24**	**0.25**	**0.24**
Accidents	0.59	0.17	0.17	0.17
Air Pollution	0.08	0.01	0.02	0.01
Greenhouse Gases	0.15	0.02	0.02	0.02
Noise	0.04	0.04	0.04	0.04

Source: Forkenbrock, 2001.

Somewhat higher values of air pollution from trucks emerge if *damage costs* are taken into account. Table 4-5 presents results from (Eyre, 1997) on damage costs associated with air pollution in rural and urban areas.[21] Values used by the Minnesota Public Utility Commission (MN PUC) for environmental costs of different pollutants (from a 2004 study by Rutgers University) [22] are presented in Table 4-6.

Table 4-5. Damage Costs of Emissions from New Vehicles (cents per mile,1996)

Vehicle Type	Rural (cents/mi)	Urban (cents/mi)
Gasoline Vehicle	0.5	1.0
Natural Gas Vehicle	1.4	3.0
Diesel Vehicle	1.9	7.4

Source: Eyre, 1997

Table 4-6. MN PUC Environmental Cost Values (Dollars per ton, 2002)

Pollutant	Urban	Metropolitan Fringe	Rural	w/i 200 miles of MN
SO_2	0	0	0	0
PM_{10}	5,060 - 7,284	2,253 - 3,273	637 – 970	637 - 970
CO	1.20 – 2.57	0.86 – 1.52	0.24 – 0.46	0.24 – 0.46
NO_x	421 – 1,109	159 - 302	20 – 116	20 - 116
Pb (Lead)	3,551 – 4,394	1,873 – 2,262	456 - 508	456 - 508
CO_2	0.34 – 3.52	0.34 – 3.52	0.34 – 3.52	0

Source: Rutgers University, 2004

Emissions Trading Approaches. Another approach to the valuation of air quality impacts is to rely on valuations set by *emission trading markets* in the US and abroad. Domestic trading markets exist for SOx and NOx, although markets for greenhouse gases (GHG) exist only abroad (under the Kyoto protocols, as adopted in Europe). Table 4-7 shows the monetized values of air pollution as adopted for Wisconsin's Focus on Energy Program. Those values were used by Wisconsin to estimate and monetize reductions in electric power plant emissions resulting from energy policies and programs.[23] However, these values do offer a potentially viable alternative basis for monetizing air pollution changes resulting from transportation policies. Further description of Wisconsin's approach to monetization of air pollution impacts is provided as a case study in the following chapter.

Table 4-7. Estimates of the Potential Value of Pollution Credits for Wisconsin's Focus on Energy Program

Type of Emission	Annual Emission Reduction	Spot Market Price (2003)	Annual Value at Current Spot (2003)	Projected Price (2012)	Annual Projected Value (2012)
SO_X (tons)	445	$130/ton	$58,000	$332-392/ton	$148,000-175,000
NO_X (tons)	264	n/a	n/a	$1,767-1,847	$467,000-488,000
GHG (tons CO_2)	110,045	$1-2/ton	$110,000-220,000	$5-10/ton	$550,000-1,100,000
Mercury (lbs)	3.1	n/a	n/a	$16,000-120,653	$49,000-371,000
Total			$168,000-$278,000		$1,200,000-2,100,000

Source: Sumi, et al., 2003 (See Bibliography source 23)

Another case in which air pollution was valued via emissions trading is found in a California study, *"Cost and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force."* That study monetized the benefits of using various "green building" technologies and the impacts on pollutant emissions. The study experienced difficulty in monetizing CO_2 emissions due to the lack of an established national trading market in the United States. The analysts were reluctant to dismiss these impacts, however, because CO_2 emissions potentially could be very costly. The study assumed a benefit value of $5 per ton in CO_2 emissions reduced, which was above the then current CO_2 trade prices in states and countries which had established markets, but below most medium-term estimates for CO_2 reduction costs. (See table 4-8.)

Table 4-8. Financial Benefits of Green Buildings (Dollars per sq. ft., 2002)

Category	**20-Year NPV**
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Water Value (construction only) – 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Gold and Platinum)	$67.31

Source: "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force," 2003.

Analysis Methods. The literature on environmental performance measures suggests that some performance measures relating to environmental benefits are commonly monetized. For some air pollutants, the existence of emissions trading markets provides information on the value of emissions reductions. The analysis methodology, as indicated in the previous section, is relatively straight forward. Another observation from the literature is that the reduction in health impacts often make up the vast majority of pollution-related benefits. As such, issues related to monetization of health benefits, including the valuation of a life saved, will drive the overall assessment of benefits.

The EPA's Science Advisory Board (SAB) has examined questions relating to monetization. Convened in 2003, the SAB has been given the charge to "provide advice to strengthen the EPA's approaches for assessing the costs and benefits of environmental programs that protect ecological systems and services, to identify research needs to improve how ecological resources are valued, and to support decision making to protect ecological resources."[24] Its initial report in April 2006, "focuses on the need for an expanded and integrated approach for valuing EPA's efforts to protect ecological systems and services."[25]

SAB also examined practical examples of monetizing ecological benefits, compiled in a May 2006 report.[26] Although focusing on water effluent, the SAB noted that there are two methods available for valuing non-use benefits: contingent valuation and conjoint analysis. Both are "stated preference methods" used to determine how people value different benefits. The contingent valuation method "involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services."[27] In a conjoint analysis, "Respondents choose between alternative products or scenarios that display varying levels of selected attributes. The utility of each attribute can be inferred from the respondent's overall evaluations."[28]

These methods can be utilized in two ways. The first is to survey residents of the affected areas in order to understand the preferences (and valuations) of persons who would be directly affected by a proposed project. The second is to apply findings from surveys of other areas, an approach termed "benefits transfer." Of these two approaches, direct surveys are more expensive, but provide a more accurate measure of local preferences. Benefits transfer is less expensive and "is most reliable when the original site and the study site are very similar in terms of factors such as quality, location, and population characteristics; when the environmental change is very similar for the two sites; and when the original valuation study was carefully conducted and used sound valuation techniques."[29]

It is worth noting that there are two approaches within the benefits transfer methodology. In the first, values derived from other studies are used directly; in the second, the benefits function from another study is used and "[adjusted] for differences in these characteristics, thus allowing for more precision in transferring benefit estimates between contexts."[30]

4.2 Monetizing Safety and Health Impacts

Safety (Crash Costs). Traffic safety impacts are typically measured in terms of crash rates, usually classified as property damage only (PDO), personal injury (measured in terms of five levels of accident severity) and fatalities. Unit costs per crash are typically established for each type of crash. Table 4-9 shows typical crash costs established by US DOT's National Highway Traffic Safety Administration (NHTSA). They range from around $2,000 for property damage and minor injury cases up to $3.4 million for fatalities.

Table 4-9. NHTSA Estimate of Crash Costs per Vehicle Accident (2000)

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	FATAL
Injury Severity		**None**	**Minor**	**Moderate**	**Serious**	**Severe**	**Critical**	**Fatal**
Medical	$0	$1	$2,380	$15,625	$$46,495	$131,360	$332,457	$22,095
Emergency Services	$31	$22	$97	$212	$368	$830	$852	$833
Market Productivity	$0	$0	$1,749	$25,017	$71,454	$106,439	$438,705	$595,358
HH Productivity	$47	$33	$572	$7,322	$21,075	$28,009	$149,308	$191,541
Insurance Admin.	$116	$80	$741	$6,909	$18,893	$32,335	$68,197	$37,120
Workplace Costs	$51	$34	$252	$1,953	$4,266	$4,698	$8,191	$8,702
Legal Costs	$0	$0	$150	$4,981	$15,808	$33,685	$79,856	$102,138
Injury Subtotal	**$245**	**$170**	**$5,941**	**$62,019**	**$178,359**	**$337,302**	**$1,077,566**	**$957,787**
Travel Delay	$803	$773	$77	$846	$940	$999	$9,148	$9,148
Property Damage	$1,484	$1,019	$3,944	$3,954	$6,799	$9,833	$9,446	$10,273
Non-Injury Subtotal	$2,287	$1,792	$4,621	$4,800	$7,739	$10,832	$18,594	$19,421
Market Cost Summary	**$2,532**	**$1,962**	**$10,562**	**$66,820**	**$186,097**	**$348,133**	**$1,096,161**	**$977,208**
Quality of Life -Nonmarket	$0	$0	$4,455	$91,137	$128,107	$383,446	$1,306,836	$2,389,179
Total Comprehensive	**$0**	**$0**	**$15,017**	**$157,958**	**$314,204**	**$731,204**	**$2,402,997**	**$3,366,388**
Non-market/ Market	0.00	0.00	0.42	1.36	0.69	1.10	1.19	2.44

Note: PDO = "Property Damage Only. MAIS = maximum injury severity level by victims.
Original Source: Lawrence Blincoe, et al., Economic Cost of Motor Vehicle Crashes 2000, NHTSA, USDOT, 2002. www.nhtsa.dot.gov/people/economic/EconImpact2000 (Also shown in VTPI, 2005)

The various categories of impact shown in the first column of Table 4-9 encompass three major classes of crash-related costs. The first class reflects the "human capital" method, which accounts only for market costs of medical treatment and lost worker productivity. The second class adds vehicle and travel time costs. The third class known as "comprehensive" cost, includes non-market costs such as pain, grief, and reduced quality of life.

Table 4-10 shows a European counterpart to Table 4-9, in which average cost per crash has been converted from Euros to Dollars at a rate of 1 Euro = $1.30 as of 2003. So whereas the US market valuation of costs associated with a moderate injury crash (from the prior table) was shown to be nearly $67,000, Table 4-10 shows the European equivalent to be just over $41,300. In addition, whereas the US market valuation of costs associated with a fatality was shown to be nearly $3.4 million, Table 4-10 indicates the European equivalent to be closer to $1.2 million. The differences between US and European values are likely due to a combination of differences in analysis methods and health care costs, as well as variation in exchange rates.

Table 4-10. European Union Crash Costs per Accident (converted from 2003 Euros into 2003 Dollars)*

	Lost Output	Human Cost	Medical Cost	Property Damage	Insurance Admin.	Police Costs	Delay Costs	Total Costs
Fatal Crash	460,314	884,615	6,197	8,594	242	1,538	11,538	1,376,734
Injury Crash	5,102	26,923	2,711	2,650	100	70	3,846	41,335
Individual Fatality	400,273	769,231	5,388	n/a	n/a	n/a	n/a	1,174,892
Individual Injury	3,752	20,000	1,993	n/a	n/a	n/a	n/a	25,745

**Note: Recalculated from the original source by converting 2003 Euros into Dollars, based on exchange rate of 1.3 US Dollars per Euro. Original Source: ICF Consulting, Cost-Benefit Analysis of Road Safety Improvement, European Union, 2003. (Also shown in VTPI, 2005) http://europa.eu.int/comm/transport/road/library/icf_final_report.pdf*

Table 4-11 displays average US crash costs per vehicle-mile rather than per crash. This cost is essentially the product of [average cost per crash] x [rate of crashes per vehicle-mile]. As a result, higher values are shown in rural areas, reflecting the higher crash rates in these areas.

Table 4-11. Estimated Highway External Crash Costs from the Federal Highway Cost Allocation Study (Cents Per Vehicle-Mile, 1997)

	Rural Highways			Urban Highways			All Highways		
	High	Med.	Low	High	Med.	Low	High	Med.	Low
Automobile	9.68	3.15	1.76	4.03	1.28	0.78	6.02	1.94	1.13
Pickup & Van	10.21	3.31	1.75	4.05	1.27	0.74	6.70	2.15	1.17
Buses	14.15	4.40	2.36	6.25	1.89	1.08	9.55	2.94	1.62
Single Unit Trucks	5.97	2.00	0.97	2.21	0.71	0.40	3.90	1.29	0.65
Combination Trucks	6.90	2.20	1.02	3.67	1.16	0.56	5.65	1.79	0.84
All Vehicles	9.52	3.09	1.68	3.98	1.26	0.76	6.12	1.97	1.11

Original Source: FHWA, Federal Highway Cost Allocation Study, USDOT, 1997. Table V-24. www.fhwa.dot.gov/policy/hcas/summary/index.htm (Also shown in VTPI, 2005)

Value of Life. Two approaches to estimating the value of a human life lead to different results. Researchers using the "Human Capital" method generally find the value of a human life between $0.5 and $1 million. The more common "Comprehensive" method leads to a greater valuation of the loss of life that is most commonly between $2 million and $7 million, with a "working value" of about $3.3 million.[31]

The December 2004 GAO workshop on economic performance measures noted that one of the problems with economic analysis was the lack of guidelines regarding monetary values of crash benefits. The prime example cited in the conference report was the "Value of a Statistical Life" (VSL). The GAO report further noted that "the US Army Corps of Engineers tends not to value statistical lives saved, while the Centers for Disease Control and Prevention (CDC) values statistical lives saved (based on a 35-year-old man, for example) at $0.94, DOT at $2.7 million, and EPA at

$6.1 million. Such differences create difficulty in comparing economic performance measures across agencies. (p.31).[32]

A recent (2005) study by Resources for the Future used an alternative VSL of $2.2 million. The authors justify this estimate by noting that "For the most important aspect, the value of a statistical life (VSL), we have used an estimate of $2.25 million (1999 dollars) from a recent meta-analysis by Mrozek and Taylor (2002) of 203 hedonic labor-market estimates. The estimate is lower then that used in most previous work and less than half of the $6.1 million estimate used by EPA (1997, 1999). The most important reason for this discrepancy is the attribution of wage rate differentials to inter-industry differences that occur for other reasons." (p.23)

Health. The South Coast Air Quality Management District, the air quality agency for Southern California, has established its own values of health and mortality rates, which are used in establishing the cost of air pollution. These values, shown in Table 4-12, reflect costs ranging from $11/person per day for acute respiratory symptoms all the way up to $4.5 million per fatality.

Table 4-12. Unit Monetization Factors Used in SCAQMD (Year 2003 Dollars)[33]

Symptom	Monetary Value
Mortality in Population < 65 Years	$4.5 million
Mortality in All Age Groups	$3.5 million
Mortality in Population >65 Years	$3.4 million
Adult Chronic Bronchitis	$240,000
Respiratory or Cardiac Hospital Admissions	$14,000
Emergency Room Visits (incl. work loss)	$500
Restricted Activity Days	$60
Asthma Symptom Days	$36
Minor Restricted Activity Days	$26
Acute Respiratory Symptom Days	$11

Source: "AQMP Health Benefits Assessment" presentation; April 11, 2006

As noted earlier, decisions on how to monetize health benefits can be the single most important factor in determining estimates of benefits. In the case of the South Coast Air Quality Management District, 32% of the total benefits associated with its 2003 air quality management plan were due to reductions in mortality (death); another 7% were due to reductions in morbidity (illness). The portion of benefits not related to health (60%) were split more-or-less evenly between visibility improvements and congestion relief. For the 2003 plan, SQAMD used the monetization factors presented in Table 4-12, which were based on Chestnut and Keefe (2003). These values are expected to be updated for the next (2007) air quality management plan.[34]

California's statewide air pollution agency, the California Air Resources Board (CARB), has established its own values for many of these same categories of health costs associated with air pollution. They are generally similar, but not the same as, the SCAQMD values, as shown in Table 4-13.

Table 4-13. CARB Valuations of Health Effects (2005 dollars) [35]

Health Endpoint	2005	2010	2020	References
Mortality				
Premature death ($ million)	7.9	8.1	8.6	U.S. EPA (1999), (2000), (2004)
Hospital Admissions				
Cardiovascular ($ thousands)	41	44	49	CARB (2003), p.63
Respiratory ($ thousands)	34	36	40	CARB (2003), p.63
Minor Illnesses				
Acute Bronchitis	422	440	450	U.S. EPA (2004), 9-158
Lower Respiratory Symptoms	19	19	20	U.S. EPA (2004), 9-158
Work loss day	180	195	227	2002 CA and US DOL wage data
Minor restricted activity day (MRAD)	60	62	64	U.S. EPA (2004), 9-159
School absence day	88	95	111	U.S. EPA (2004), 9-159

[1]*California Air Resources Board, Quantification of the Health Impacts and Economic valuation of Air Pollution From Ports and Goods Movement in California (2006), Table A-8.*

Finally, another source for health valuations comes from OECD's Climate Change panel, which held a conference in 2000 on the costs and benefits of greenhouse gas reduction strategies. As part of the conference, Davis, et al. presented a paper on health benefits and costs, which included a summary of monetary valuations for a range of health benefits.[36] These benefits and costs are reproduced in Table 4-14. Note that a range of estimates is provided for the US, Canada, and Europe.

Table 4-14. A Summary of International Health Valuations (1999 Dollars)

Values	US EPA[a]			US TAF[b]			Canada AQVM[c]			Europe ExternE[d]
	Low	*Central*	*High*	*Low*	*Central*	*High*	*Low*	*Central*	*High*	*Central*
Mortality	1560000	4800000	8040000	1584000	3100000	6148000	1680000	2870000	5740000	3031000
Chronic Bronchitis	-	260000	-	59400	260000	523100	122500	186200	325500	102700
Cardiac Hosp. Admissions	-	9500	-	-	9300	-	2940	5880	8820	7696
Resp. Hosp. Admissions	-	6900	-	-	6647	-	2310	4620	6860	7696
ER Visits	144	194	269	-	188	-	203	399	602	218
Work Loss Days	-	83	-	-	-	-	-	-	-	-
Acute Bronchitis	13	45	77	-	-	-	-	-	-	-
Restricted Activity Days	16	38	61	-	54	-	26	51	77	73
Resp. Symptoms	5	15	33	-	12	-	5	11	15	7
Shortness of Breath	0	5.3	10.60	-	-	-	-	-	-	7
Asthma	12	32	54	-	33	-	12	32	53	36
Child Bronchitis	-	-	-	-	45	-	105	217	322	-

a. The Costs and Benefits of the Clean Air Act Amendments of 1990. Low and high estimates are estimated to be 1 standard deviation below and above -mean of the Weibull distribution for mortality. For other health outcomes they are the minimums and maximums of a judgmental uniform distribution.
b. Air Quality Valuation Model Documentation, Stratus Consulting for Health Canada. Low, central, and high estimates are given respective probabilities of 3 34%, and 33%.
c. Tracking and Analysis Framework, developed by a consortium of U.S. institutions, including RFF. Low and high estimates are the 5% and 95% tails o distribution.
d. ExternE report, 1999. Uncertainty bounds are set by dividing (low) and multiplying (high) the mean by the geometric standard deviation (2).

Source: Krupnick, et al., 2000

4.3 Monetizing Accessibility, Mobility and Time

Accessibility and mobility are related concepts that are often confused. ***Accessibility*** refers to the ability of a population to reach various types of destinations and participate in various types of activities including jobs, health care centers, housing, shopping, and recreation. ***Mobility*** refers to the ability to move from one place to another, which is facilitated by availability of the transportation modes. It is possible to have one without the other. For example, a neighborhood where few households have cars may have excellent public transportation on east-west routes, but few options for north-south travel. If most of the regional jobs are located north or south, this neighborhood may be considered to have high mobility but low job accessibility. Similarly, with the advent of internet shopping and banking, consumers can now have almost instant access to a wide range of opportunities, without travel.

Accessibility. Accessibility measures are one component of social equity in access to transportation, and are difficult to monetize. The US DOT's accessibility goals and measures largely deal with access to pubic transit under ADA (the Americans for Disability Act) regulations, and are currently discussed under the Department's mobility goals, which include: [37]

- Percent bus fleets compliant with the ADA
- Percent of key rail stations compliant with the ADA
- Number of employment sites (in thousands) that are made accessible by Job Access and Reverse Commute transportation services.

NCHRP Report 446 and the FHWA Report FHWAOP-03-080 define accessibility more broadly as the ability of people and goods to access transportation services. Examples of performance measures include: "density" of opportunities enabled by transportation services (e.g., the number of households within a 30-minute drive of key regional centers, or the number of employment opportunities within a 10-minute walk of transit stops) or the ability of a facility to serve a particular user group (e.g., a particular segment of population or type of freight).

A broader array of accessibility measures has been defined by Litman (2005):[38]

- *Quality of overall accessibility*: ability to reach desired goods, services and activities.
- *Basic access:* quality of transport to access socially valuable activities such as medical services, education, employment and essential shopping, particularly for disadvantaged populations.
- *Land use mix:* number of job opportunities and commercial services within 30-minute travel distance of residents.
- *Land use accessibility:* average number of basic services (schools, shops and government offices) within walking distance of residences.
- *Children's accessibility:* portion of children who can walk or bicycle to schools, shops and parks from their homes.

- *Transport diversity:* variety and quality of transport options available in a community. (This also includes accessibility in the case of emergencies and unforeseen circumstances such as during car repairs.)

Mobility. USDOT defines mobility as "accessible, efficient, intermodal transportation for the movement of people and goods," thereby incorporating some of what is commonly included in the definition of performance measures for accessibility, discussed above. USDOT's performance measures for mobility, all quantified, but not monetized, are:[39]

- Percentage of travel on the National Highway System (NHS) meeting pavement performance standards for good rated ride.
- Percent of total annual urban-area travel occurring in congested conditions.
- Average percent change in transit boardings per transit market (150 largest transit agencies), adjusted for changes in employment levels.
- Percent bus fleets compliant with the ADA.
- Percent of key rail stations compliant with the ADA.
- Number of employment sites (in thousands) that are made accessible by Job Access and Reverse Commute transportation services.
- Percent of all flights arriving within 15 minutes of schedule at the 35 Operational Evolution Plan airports due to NAS-related delays.

Recommended measures for mobility, some of which have been previously used by U.S. DOT, include: [40]

- *Commute speed* - Average commute travel time.
- *Congestion delay* - Per capita traffic congestion delay.
- *Transit service* – Public transit service quality, including coverage (portion of households and jobs within 5-minute walking distance of 15-minute transit service), service frequency, comfort (portion of trips in which passenger can sit and portion of transit stops with shelters), affordability (fares as a portion of minimum wage income), information availability, and safety (injury rate)
- *Motor Transport Options* - Quantity and quality of airline, rail, public transit, ferry, rideshare and taxi services.

Value of Truck Time and Reliability. A growing number of states are now starting to implement separate truck models for estimating or measuring the flow of freight. There has also been significant effort to improve the measurement of traffic delay impacts on cargo movements, and the associated full costs to users of the freight transportation system – which is defined to include not only driver and vehicle costs, but also broader inventory and logistics costs of delay. A widely used starting point is FHWA's Highway Economic Requirements System (HERS). That system provides value of time delay for different uses and types of vehicles. These are presented in Table 4-15, which shows that an hourly value of business travel of roughly $32 per hour, with lower rates for cars and smaller trucks.

Table 4-15. Average Value of Time, Based on Vehicle Cost per Hour of Travel (1995 Dollars)

$ per Person-Hour	Vehicle Class						
Category	Small Auto	Medium Auto	4-Tire Truck	6-Tire Truck	3-4 Axle Truck	4-Axle Comb.	5-Axle Comb.
On-the-Clock							
Labor/Fringe	26.27	26.27	8.02	21.88	18.22	21.95	21.95
Vehicle	1.72	2.02	2.18	3.08	8.80	7.42	7.98
Inventory	0.00	0.00	0.00	0.00	0.00	1.65	1.65
Total	27.99	28.29	20.20	24.96	27.02	31.02	31.58
Other Trips							
Percentage of Miles	90%	59%	0%	0%	0%	0%	0%
Value	12.78	12.78	NA	NA	NA	NA	NA
Weighted Average	14.30	14.33	15.08	25.27	27.91	31.64	32.25

Source: Source: Federal Highway Administration, The Highway Economic Requirement System: Technical Report (updated 3/97). [41]

When possible, the values presented in this table should be tailored to the study area by using data on local vehicle occupancy rates and vehicle operating costs (reflecting changes in fuel costs). However, there is controversy about also adjusting the labor cost element for differences in wage rates among areas, since in some situations that could bias results by giving greater benefit value to transportation projects in richer areas than in poorer areas.

Some recent studies have also incorporated additional value of time for freight logistics costs, which can also increase significantly with truck delays. (These can include additional costs of delay associated with idle workers at loading docks, overtime pay, rescheduling warehouse processing activities and sometimes also maintaining backup inventories for just-in-time manufacturing and distribution.) For instance, a recent Montana study used differing values of time delay depending on the type of passenger or freight occupancy of the vehicle (see Table 4-16).

Table 4-16. Value of Time Delay for the Montana Reconfiguration Study

Type of Vehicle and Passenger/Cargo	Hourly Cost of Delay (2004)
Non-Durables Manufacturing Goods	$53
Durables Manufacturing Goods	$66
Agriculture	$41
Mining & Wood Resources	$39
Misc. Transport Services	$42
Drayage & Warehousing	$40
Non-Freight (Service Delivery)	$38
Auto – Work	$13
Auto – Non-Work	$ 6

Note: calculations based on HERS framework with ES-202 wage statistics, and industry cost economic analysis model by Economic Development Research Group, Inc.

Source: Economic Effects of Reconfiguring Montana Two-Lane Highways [42]

The monetary value of travel time delay for trucks may be even greater than indicated in this table. *NCHRP Report 431* examined the value for time savings for trucks by using a stated preference survey of truck carrier companies. It found that carriers valued freight delivery time at an average of $144–$192/hour. It also found that carriers value avoidance of schedule delay at a larger $371/hour, reflecting the larger loading and logistics costs involved in those situations. Based on that finding, the report recommended a mark-up factor of 2.5 to the value of time when the time savings are under highly congested conditions. [43]

This mark-up factor is generally consistent with many other studies of the valuation of truck travel time variability. A study by Cohen and Southworth found that the cost of truck delay under congested conditions can run between 2 and 6 times the normal value of travel time, depending on the particular conditions of the applicable freeways.[44] Mahady and Lahr concluded that truck carrier costs under congested conditions tend to be 1.3 to 2.4 times the normal value of time.[45]

Other studies of travel time reliability have focused more on passenger cars, and sought to determine the value of a one minute "standard deviation" of travel time (a measure of variation) during peak periods. Noland and Polak found that it has a value between 1 and 3 times the normal value of time,[46] while Liu et al. found a ratio as high as 1.2 to 2.8 times the normal value of time.[47]

4.4 Monetizing Economic Development Impacts

Economic development commonly refers to changes in business activity that expand (and improve the nature of) jobs and income for residents of an area. Transportation improvements generally create economic development through two mechanisms: (1) by reducing costs for existing transportation movements in the area, and (2) by expanding the market access and connectivity available from that area, making it possible for new kinds of activity to occur there. Both mechanisms can lead to expansion of existing businesses and attraction of new businesses, and they both do so by enhancing the productivity and profitability of operating in the affected area.

Use of Economic Development Measures. Economic development benefits are of particular interest to many state and regional agencies because economic development can be an important motivator or even the primary reason for some transportation investments. *NCHRP Synthesis 463* included a survey of state DOTs concerning the use of economic development impact measures in highway investment decisions. Two-thirds of the states surveyed reported that they conduct evaluations of economic impacts at least occasionally, although a much smaller portion routinely conduct evaluations of completed projects.[48]

Economic development impacts are similar to environmental impacts in that they are also multi-faceted. For instance, economic development impacts can be quantified in terms of changes in jobs, personal income, value added (personal income plus corporate profits), or business sales (output). However, unlike environmental impacts, they cannot rely on standard rules of thumb for monetization instead they require the use of economic models. The various approaches that can be used for measurement and analysis of economic development performance impacts are described here.

Types of Economic Development Measures. The selection of appropriate economic impact measures depends on the fundamental economic goals of the transportation project. Economic goals might include promoting economic growth, diversifying away from traditional industries, or creating jobs in blighted areas. The types of economic development goals, and hence performance measures, include:

- *Intermediate Results.* These are shorter-term direct impact measures. They include such things as growth in construction jobs, land investment, and time savings and other cost efficiencies for businesses and residents.

- *Final Outcome Measures.* These are the consequences or results of what the program did to achieve the objectives of the project. They may include:

1) *Business Growth*. This is the net contribution of the project to the growth of economic prosperity, measured in terms of overall growth in business activity.

2) *Business Mix.* For projects aimed at supporting economic diversification, indicators can reflect change in the composition of the area's economic base.

3) *Economic Equity and Social Welfare.* For projects aimed at helping to ameliorate social inequities, indicators can reflect the incidence of benefit among target groups.

Business Growth Performance Measures - Among these various indicators, attention is most commonly placed on measures of the expected and actual impact of transportation projects on overall economic growth. This is most commonly measured in terms of:

- *Jobs* -- Growth in jobs is easy to understand for both policy makers and the public and is easy to document using publicly available statistics.[49] However, it is not a monetized value, and so it cannot be used in Benefit/Cost (B/C) analysis or Return on Investment (ROI) analysis.

- *Income* -- When monetizing impacts, the most commonly used measure of impact is income – either Personal (Wage) Income or the slightly broader measure of Value Added (which reflects worker wage income and net corporate income from profits). Value added is also equivalent to Gross Domestic Product.

- *Output* -- Finally, business growth can be monetized in terms of business output, which includes reflects total business sales. This last measure provides the largest values, though it can be deceiving because it counts full value to business sales volume regardless of how much of the worker payroll and net corporate income is generated locally. Yet the change in real output of business sales can indicate how the cost savings or productivity gains associated with the transportation improvement affect business decisions to expand production or increase sales in the region.

Industry Mix Performance Measures – Transportation projects can affect the attractiveness of an area for particular types of commercial or industrial activity, and thus change the mix of jobs and business. For areas that have narrow economic bases or otherwise need to diversify away from threatened industries, it can therefore be instructive to monitor changes not only in total business activity, but also in the ranges and composition of businesses in the region. Indicators of change in an area's industry mix can include:

- Changes in number and percent of jobs in high growth/slow-growth industries
- Changes in number and percent of jobs in high paying/low paying industries
- Change in growth of key target industries (e.g., tourism, export base, or technology base)

Socio-Economic Welfare and Equity Performance Measures. These measures are often overlooked in analysis of economic benefit. They can indicate improvements in access to economic opportunities among all groups within the community, and particularly target areas (regions or neighborhoods) that have historically faced economic hardship. They include:

- Unemployment in the labor force
- Percent of population below poverty

Drivers of Economic Development Change. The major business site location factors that are directly affected by transportation include access and costs associated with materials, workforce and customer/delivery markets.[50] Based on the literature, there are essentially three types of changes directly caused by transportation projects and programs:

a) *Changes in Spending* – on vehicles, buildings, facilities, or other materials as a result of either initial investment or ongoing operations and maintenance

b) *Changes in Traffic Flow* – volume of vehicles, occupancy, travel times and travel distances (changing vehicle-miles of travel and vehicle-hours of travel)

c) *Changes in Access* – affecting labor market access and scale, customer/ delivery market access and scale, access to recreation opportunities, inter-modal connectivity to airports, ports, rail terminals and border crossings

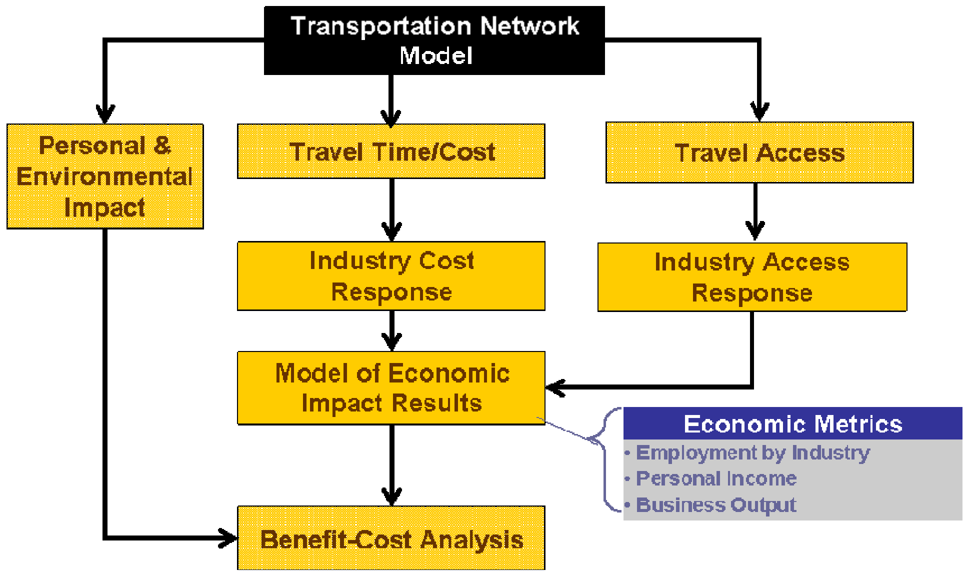
Monetization Models. The three categories of direct transportation change can be *input* into economic models, which then calculate *outputs* representing the broader impacts on the regional economy (which can be measured in terms of jobs, income or business output). The range of economic impact models and the ways in which they can be used are described in *NCHRP Synthesis Report 290.* [51] The evolution of these tools and recent advances in their use are also described in Weisbrod (2006).[52] The primary tools are regional economic simulation models, traditionally the REMI model and more recently adding the REDYN model and TREDIS-CRIO model, to calculate how state or regional economic growth occurs from shifts in spending flow through the economy (item "a" in the preceding list), and shifts in travel costs (item "b" in the preceding list).

While many states have occasionally used regional economic simulation models for assessing benefits of major highway projects, these techniques have not had broad use for statewide or region-wide performance metrics. One reason is that they have been expensive to use; another reason is that such models alone can significantly under-estimate the true value of transportation projects by totally missing the effect of improving mobility, system connectivity and access to markets (item "c" in the preceding list).

To address that problem, a number of agencies including Montana DOT,[53] Indiana DOT,[54] Wisconsin DOT,[55] the Appalachian Regional Commission (ARC),[56, 57] Portland Metro Council[58] and Oregon Business Alliance[59] have turned to broader techniques that also capture the business growth effects of connectivity and inter-modal port access improvements. These techniques marry one of the above-cited economic simulation models with a separate business attraction model that is sensitive to market access and connectivity improvements and their impact on productivity. Indiana's Major Corridor Investment-Benefit Analysis System (MCIBAS) and Montana's Highway Economic Analysis Tool (HEAT) are examples of integrated systems that bring these tools together. Case studies in the next chapter describe the use of such methods by Montana, Indiana and the ARC. All three of these case study examples cover both business cost savings for existing business and new business attraction effects, and encompass the set of impact elements shown in Figure 4-1.

One note about the Figure 4-1 flowchart is that it distinguishes impacts that affect the flow of dollars in the economy from impacts that can be measured in dollars, but do not actually affect the flow of money. Personal travel time and environmental factors (shown on the left side of the flowchart) commonly fall into the latter category, particularly when they are based on "willingness to pay" concepts, inferred from either revealed preferences (behavior) or stated preferences (surveys). Those types of impacts should be fully counted as benefits in benefit-cost analysis, but should not be input into models of a regional economy unless there is evidence that they actually generate income in the economy greater than the societal preference valuation that they have already been given.

Figure 4-1 Elements of Analysis for Assessing Economic Impacts of Transportation Programs or Projects



Accounting for Overall Economic Impacts. In practice, economic development impacts often reflect the net effect of many offsetting factors. An illustration is provided by the Asian Development Bank (ADB) in its *Handbook Integrating Impact Assessment in the Economic Analysis of Projects*.[60] It identifies the economic impacts of a new bridge as being driven by a variety of changes that span all three categories of direct effect, including:

- Savings in vehicle operating costs and driver time
- Value of freight and passenger time savings
- Benefits generated by the new traffic
- Losses to existing ferry operators
- Savings of not having to construct a power-interconnector (which would have needed to be built without the new bridge)
- Environmental benefits of erosion prevention and increased agricultural production

Expanding the example to many projects, it becomes clear that the overall regional impact of a program of many projects must be calculated as the net sum of impacts of these various elements of spending, traffic flow and access changes.

It is also important to recognize that regional or state boundaries can affect the measurement of impacts. For instance, a highway improvement in one region can enhance access and productivity for businesses in adjacent regions. That phenomenon has been shown in various studies of the Appalachian Regional Commission.[61] A highway improvement can also cause business location shifts among regions.

However, it is important to note that even a shift in business location among regions is not necessarily a zero net benefit to society as long as there is some productivity enhancement associated with the relocation. This is the case with transportation improvements, since no rational business would undergo the transaction costs of relocation unless there was some resulting profitability gain from doing so. (The concept that business relocations have no net societal benefit comes from literature on the value of local tax incentives, which unlike transportation improvements can change business costs without affecting productivity).

Finally, it is also important to distinguish economic development impacts from other benefit indicators used in benefit-cost analysis. Table 4-17 shows the difference in definitions of economic development impact from various alternative benefit measures of travel efficiency, user benefit and societal benefit.

Among the columns shown in this table, the measures of "travel efficiency benefit", "full user benefit" and "societal benefit" represent increasing breadth of benefit coverage that can be considered in a benefit/cost analysis. The measure of "economic development impact" covers many of the same elements as those three benefit measures, but it is distinct from them because it is a measure of impact on an area economy. Economic development impact is usually measured in terms of changes in the flow of dollars (income and business sales) in the economy of an area and the associated jobs occurring there. As such, it can include the change in local income growth that comes just from attracting businesses to shift locations (which is not counted in benefit/ cost studies), and it can leave out other benefits that do not directly affect the flow of dollars and jobs in the economy (such as air quality and the value of personal time, which can be counted in benefit/cost studies).

Table 4-17. Difference between Economic Value of Benefits and Impacts on the Economy

	Travel Efficiency Benefit	Full User Benefit[1]	Societal Benefit	Econ Development Impact
$ Travel Time Savings for personal travel	Yes	Yes	Yes	-- [7]
$ Travel Time Savings for business travel	Yes	Yes	Yes	Yes
$ Vehicle Operating Expense Savings	Yes	Yes	Yes	Yes
$ Shipper/Recipient Productivity Gain[2]	--	Yes	Yes	Yes
$ Downstream Productivity Gain[3]	--	--	Yes	Yes
$ Value of Environmental Benefits[4]	--	--	Yes	-- [7]
$ Income Growth from Business Attraction [5]	--	--	-- [6]	Yes

1 Transportation system users are defined as the travelers for passenger travel and the shippers for freight travel
2 defined as additional net income produced through cost savings or scale or production economies for shippers
3 "downstream" income effects on other businesses that indirectly also realize productivity or cost benefits
4 value of air quality, water quality, noise improvements, expressed in terms of "willingness to pay"
6 Attracting additional business activity from one location to another is only a societal benefit insofar as there is a benefit of redistributing income growth from richer areas to poorer areas.
7 Personal time savings and environmental improvement do not directly affect the flow of dollars in the economy (though in theory there could be cases where they lead to indirect changes in economic patterns if these impacts are large enough to actually affect migration rates).

5. CASE STUDIES

This chapter presents five case studies, selected to illustrate the development and use of monetized performance measures using the various techniques discussed in Chapter 4. The chapter is organized into six parts: (1) overview of the case study approach, (2) a case study of Austroads (Australia and New Zealand), (3) a case study of the Appalachian Regional Commission, (4) a case study of Florida DOT, (5) a case study of Montana MDT and Indiana DOT, and (6) a case study of Wisconsin's Focus on Energy initiative.

5.1 Overview of Case Study Approach

Selection of Case Studies. The case studies were selected to illustrate how different types of public agencies are developing and using various monetization measures, including environmental, health, mobility and economic development impacts. It includes a range of cases, including several state transportation departments, an overseas transportation association, an economic development agency and an energy agency. This selection was intentionally diverse to illustrate both "state-of-the-art" implementation by leading transportation agencies and the potential for "information transfer" by learning from non-transportation agencies.

Content of Case Studies. The case studies differ in emphasis, but all have the same basic organization and content. They are organized in five basic parts, covering:

1. ***Background*** **–** Description of the organization and why it was selected for more detailed investigation.
2. ***History of Monetization*** **–** Performance measure categories that are being monetized, how that has changed over time, why it has changed and the role of technical, regulatory and institutional factors in those changes.
3. ***Technical Guidance that Emerges from Case Study*** **–** Approaches used to compare benefits among projects, specific monetization techniques that are used, data and organizational requirements, priorities for emphasis and expected future changes.
4. ***Role of Monetization in Organizational Decision-Making*** **–** Role and of monetized benefit measures for decision-making and public information processes, factors that currently are (and are not) being monetized, and reasons some performance elements are not monetized
5. ***Conclusions*** **–** Strengths and weaknesses of monetization approaches, and transferability of monetization approaches to other agencies.

5.2 Case Study: Austroads (Australia and New Zealand)

Background

Organization - Austroads is an association of Australian and New Zealand road transportation agencies whose purpose is to provide professional support and examples of best practice in planning, designing and managing the road network. Its members include the six Australian State and two Territory transportation agencies, the national department of transportation, and Transit New Zealand, the national transportation agency for New Zealand. Similar to the American Association of State Highway and Transportation Officials (AASHTO), Austroads is governed by a committee consisting of the chief executive officer of each of the member organizations. And also similar to AASHTO, the guidance and standards development of Austroads has a strong influence on standard transportation engineering practice in both countries.

Case Study Selection - The reason why Austroads was chosen for a case study was because its guidance on project selection, and the relationship between this decision and system performance, is one of the few examples in the world where monetized costs have been associated with a wide range of externalities. For example, Austroads recommends monetary values for such considerations as noise, air pollution, water pollution, greenhouse/climate change, nature and landscape, and urban separation (that is, sprawl).

History of Monetization

As noted in an Austroads report, "the valuation of environmental externalities is a complex and challenging area."[62] Coming from the British tradition of analysis-driven policy making, both the Australian and New Zealand transportation authorities have a long history of using benefit/cost analyses as an important input into the decision making process. Similar to state transportation departments in the United States, Australian and New Zealand transportation agencies have monetized for many years typical measures relating to travel delay, vehicle operating costs, and reductions in crashes. These measures were the professionally accepted indicators of the effect of transportation improvements on transportation system performance and on system users.

However, beginning in the late 1990s and gaining even more momentum in the early 2000s, public policy in both Australia and New Zealand has become much more sensitive to the concept of sustainability and the long-standing impacts of changes in the transportation system to such things as climate change, urban livability, public health and the functionality of land. Beginning in the early 2000s, Austroads undertook several studies to monetize externality costs associated with a range of topics that were of interest to the heads of the transportation agencies. These studies

related environmental externality costs to the respective country's gross domestic product, and then estimated costs on a per vehicle-kilometer basis.
Tables 5-1 and 5-2 show the externality cost unit values for both passenger cars and freight vehicles. Something currently under consideration is the use of an Extent of Externality Recovery (EER) indicator, which would provide an indication of the extent to which a project (or an entire investment program) minimizes the consumption of sensitive and non-renewable resources. These externality unit cost values can also be applied at a transportation systems level to determine the monetized externality costs associated with different components of the environment within which transportation operates. Table 3 summarizes the results of this calculation.

(Note: New Zealand agencies have pursued a wider range of road-related impacts that has followed the lead of Austroads. For example, Transfund New Zealand, the primary road funding agency in New Zealand, has developed monetary estimates for public health benefits associated with transportation projects--$0.50 per new walker and $0.30 per new bicyclist….the guidance did not discuss how one would forecast the number of new walkers or bikers for a project.)

Table 5-1: Summary of Externality Unit Costs (Passenger Cars)

Externality	Urban (cents per veh-km)	Rural (cents per veh-km)
Noise	$0.70	$0.07
Air Pollution	$2.10	$0.02
Water Pollution	$0.30	$0.03
Greenhouse/Climate	$1.40	$1.40
Nature & Landscape	$0.04	$0.40
Urban Separation	$0.50	0
Total	$5.50	$1.90

Source: Austroads. 2003. *Guide to Project Evaluation, Part 4: Project Evaluation Data*. Sydney, New South Wales, May.

Table 5-2: Summary of Externality Unit Costs (Freight Vehicles)

Externality	Urban ($/1,000's tonne-km)		Rural ($/1,000's tonne-km)	
	LCV	Rigid	LCV	Rigid
Noise	$23.00	$2.30	0	0
Air Pollution	$100.00	$22.00	$1.00	$0.22
Water Pollution	$15.00	$3.30	$0.15	$0.03
Greenhouse/Climate	$42.00	$4.00	$42.00	$4.00
Nature & Landscape	$15.00	$3.30	$0.15	$0.03
Urban Separation	$22.00	$2.00	0	0
Total	$217.00	$36.90	$43.30	$4.28

Source: Austroads. 2003. *Guide to Project Evaluation, Part 4: Project Evaluation Data*. Sydney, New South Wales, May.

Technical Guidance that Emerges from Case Study

Approach - The externality unit costs presented above are easily used in project benefit/cost analysis and, as shown in Table 5-3, can even be aggregated to a systems performance level. At the project analysis level the unit values are simply multiplied by the change in transportation consumed to obtain an estimated dollar value of impact. At the systems level or at the much broader system indicator level these unit costs can be multiplied by the total amount of transportation consumed (that is, vehicle- or ton-kilometers) to obtain some estimate of the externality cost associated with system performance.

The key challenge in using such an approach for monetizing non-traditional measures is identifying the underlying relationships between the particular measure and the costs associated with it. Thus, for example, air pollution externality costs are estimated on the basis of the percent increase in daily death rates that occurs when the concentration of a pollutant increases. These relationships are usually based on medical studies that establish the linkage between the two variables. As an illustration, in New Zealand, the annual mortality costs are estimated to be NZ$30 per person exposed per year per microgram per cubic meter increase of PM_{10}. These estimates, and those for other health-related measures, come from health studies that correlate mortality rates with PM_{10} exposure levels, and then link the societal costs of a death to the mortality rate-exposure relationship.

The valuation of noise impacts reflects the impact of higher noise levels on property values. Austroads relies on research that has been conducted in Europe and Canada that has relied on hedonic pricing to suggest the typical costs of noise. In almost all case, the impact is defined as a percentage of the affected properties' value. Thus, in New Zealand, for example, Transit New Zealand used a 1.2 percent value of the properties affected per decibel of noise increase as a monetized estimate of the impacts of increasing noise levels. Based on average property values, the monetary value associated with changes in noise is a net present value of NZ$1,800 per decibel per property and NZ$620 per decibel per affected resident.

The most interesting eternality measure shown in Table 5-3 is urban separation. This measure is intended to be a surrogate for an indication of the degree to which transportation investment is achieving sustainable development goals. The monetization of the urban separation measure assumes that shorter travel distances and fewer miles (hours) traveled provides for a more connected urban area. The value of travel time and the corresponding reduction in travel time are used to represent "urban separation" impacts.

Table 5-3: Transport System-Related Externality Costs

Total $m (%)	Noise	Air	Water	Greenhouse/ Climate	Landscape/ Nature	Urban Separation
Urban $11,610 (90%)	$1,541 (100%)	$5,752 (98%)	$848 (97%)	$1,689 (63%)	$577 (82%)	$1,203 (100%)
Rural $1,230 (10%)	0%	$100 (2%)	$25 (3%)	$976 (37%)	$129 (18%)	0%

Total $m (%)	Noise	Air	Water	Greenhouse/ Climate	Landscape/ Nature	Urban Separation
Passenger $5,623 (44%)	$703 (46%)	$2,118 (36%)	$313 (36%)	$1,942 (73%)	$145 (21%)	$402 (33%)
Freight $7,217 (56%)	$838 (54%)	$3,735 (64%)	$560 (64%)	$723 (27%)	$560 (79%)	$801 (67%)

Source: Austroads. 2003. *Guide to Project Evaluation, Part 4: Project Evaluation Data*. Sydney, New South Wales, May.

Data – The data requirements for this approach toward monetizing environmental and community impacts are quite extensive, and relate directly to the ability of a sponsoring agency to determine the externality unit costs. As shown in Tables 5-1 and 5-2, the forecasted variables are simply vehicle- and ton-kilometers, both of which are fairly straight forward in terms of modern network forecasting models. The underlying data needs are in establishing the relationship between a measure's impact and the monetary cost associated with it. As noted earlier, much of the cost estimation relies on medical and public health studies that give a range of externality unit costs. If such studies exist, they can be used to provide cost estimates. If they do not exist, then monetizing externality costs as shown above would require large-scale studies to develop the necessary unit cost values.

Organizational Requirements - Because Austroads is a member-supported organization, the guidance it produces reflects what the member agencies believe is important in road program management, but it does not mean that member agencies will adopt the guidance as part of their standard practice. Transit New Zealand, however, has adopted the monetization approaches found in the guidance (in fact, many of the concepts originated in New Zealand); other Australian states have adopted various aspects of the monetization approach. In most cases, the reasons why the approach has not been adopted by all member agencies is that there is still some uncertainty associated with the monetary units associated with the externality costs. In Australia and New Zealand, research is being conducted to improve these unit cost values.

In the US, it is not clear if the described monetization approach would be adopted by many state transportation agencies at this point in time. At the project level, monetization of environmental impacts such as noise and air pollution makes sense, and can be conceptually appealing in that the same unit values would be applied in comparing one project to another. In other words, the relative difference among the alternatives is the most important issue at the project level and holding the unit cost values constant across all alternatives, even if there is some uncertainty with the values, would still provide a relative comparison. However, in using the unit values in a regional performance monitoring capacity, the values of the unit costs becomes very important because they would be interpreted in a very real sense of being a "cost to society." In this context, public perceptions and difficulty in understanding the underlying principles could be a cause of concern to state transportation officials.

Role of Monetization in Organizational Decision-Making

The guidance provided by Austroads is followed by most transportation agencies in Australia and New Zealand. In most cases, because of the tradition of analysis-based decision making (and the use of benefit/cost analyses), the initial screening of the candidate projects occurs within the planning arm of a particular agency. This screening process separates those projects having little or no societal value from those that, based on benefit/cost analysis, show positive gains to society. Once projects pass this screening process, the monetized evaluation information, along with other non-monetized information, is presented to top management for final selection. Those contacted as part of this case study suggested that the relative importance of having monetized information and of using a benefit cost analysis approach varies by type of project and by the level of controversy. In routine cases, decision makers use the monetized information as an important consideration in choosing among alternatives. For major projects, that is, those that will have significant impacts on a local community or those that have strong political backing, the monetized information is usually part of a much larger evaluation tableau that presents a broad set of information on the many different variables that might be important to the decision makers.

Given the transparent planning environment found in both Australia and New Zealand, monetized values are often presented (and debated) in public forums. The use of such measures does not seem to be the major issue….the concept of monetizing benefits is generally accepted. However, the biggest debate usually surrounds the value of the unit costs, with environmental groups arguing that they are underestimated, and those more supportive of highway building arguing that they overestimate the societal cost of such impacts. In some cases, such as in New Zealand, the agency responsible for providing transportation dollars to operating agencies (such as Transfund New Zealand) requires the use of benefit cost analysis and the monetization as much as possible of the many variables that are important in investment decisions. Thus, in both Australia and New Zealand, monetized values are used both internally as well as in public outreach efforts.

Given the emphasis on planning, it is not surprising that the range of information produced in typical project evaluations in Austroad member agencies is quite broad. Much of this information is monetized because of the use of benefit cost analysis in the evaluation process. However, there are many other impact categories that are reported on, but which do not have monetized values attached to them. In examining project evaluations and system performance report cards, the major categories of performance measures that do not have monetized values attached to them (but, in many cases, could) include economic development, trade flows (this is an important issue given where both Australia and New Zealand are located geographically), visual impacts, and effects on indigenous populations.

The approach toward monetization of environmental and community impacts as embodied in the Austroads guidance provides an important opportunity to incorporate into benefit cost analysis measures that are traditionally reported only in numerical or quantity terms (for example, number of tons of CO_2 or number of acres of wetland disturbed). In addition, given the importance that both Australia and New Zealand are placing on sustainable development, this approach seems to be one that also helps illustrate the transportation community's efforts to consider such an issue in investment decision making. However, the use of such monetization measures implies agreement on the monetized valuation assigned to each performance measure category. As was noted by both Austroads and Transit New Zealand, additional research is underway to provide better estimates of the monetary value associated with each category. In addition, the "Extent of Externality Recovery" indicator is still being examined to determine whether it presents a meaningful indicator of how transportation system externalities are changing over time.

Conclusions

Australian and New Zealand transportation agencies have developed an approach to project evaluation and to some extent regional system performance monitoring based strongly on the monetization of as many performance impacts as possible. This is due in part to the legacy of a rational planning process that characterizes many of the British Commonwealth nations, but also to a desire on the part of transportation officials to obtain the best value for the limited level of resources available for investment. One of the reasons why so much effort in project and program guidance has been devoted to environmental impacts is because of the rising societal concern in both countries for environmental quality and more generally sustainability.

Of great interest in the list of performance measures monetized in the Austroads guidance was the measure relating to urban separation. This is a unique measure that is intended to reflect the impact of transportation investment on land use patterns and thus on the livability of urban communities. It is not clear, however, that the surrogate measures for this issue, that is, travel time and travel distance, really measure the level of compactness or livability of an urban area.

The major strengths of the monetization approach recommended by Austroads are: 1) being able to incorporate into benefit cost analysis monetized benefits of a large number of impacts that often characterize project decisions, and 2) assuming that the unit value associated with each measure is accepted, the public could understand the concept of how transportation investment causes additional environmental costs to society. The major weakness is that the entire approach is based on the validity of the unit costs for each externality. In the absence of defensible unit costs for a particular context, the only options available to a transportation agency would be to borrow similar costs from elsewhere or sponsor research that focuses on the linkage between transportation-induced changes and resulting impact outcomes (and the associated costs).

5.3 Case Study: Appalachian Regional Commission

Background

Organization - The Appalachian Regional Commission (ARC) is a unique regional economic development agency that comprises a partnership of federal, state and local governments. Congress established the ARC in 1965 to address the significantly higher poverty levels and lower living standards found in the Appalachian region compared to the rest of the nation. (When established, the ARC region covered a twelve state area, including all of West Virginia and parts of eleven other states. The boundaries have been expanded twice since its inception, and now include 399 counties in thirteen states stretching from New York to Mississippi. The region encompasses 200,000 square miles.)

Case Study Selection – The reason that ARC was selected as a case study was because it illustrates a regional agency with primarily economic development objectives that works closely with state DOTs to fund and implement a series of highway and road projects. That situation has led ARC to implement a series of economic development performance measures applied to highway investments. It also illustrates how an agency can use economic performance measures for both predictive (pre-project) and evaluative (post-construction) analyses.

Agency Overview

The ARC's purpose is to promote socioeconomic growth in its 399-county region, which covers all or part of 13 states, through advocacy, investment in infrastructure, regional planning, research, grant making, and educational programs. The goals of the agency, as stated in its 2005-2010 Strategic Plan are:

- "Increase job opportunities and per capita income in Appalachia to reach parity with the nation.
- Strengthen the capacity of the people of Appalachia to compete in the global economy.

- Develop and improve Appalachia's infrastructure to make the Region economically competitive.
- Build the Appalachian Development Highway System to reduce Appalachia's isolation."[63]

The ARC's goals are achieved through three distinct programs. The Highway Program, called the Appalachian Development Highway System (ADHS), was created "expressly to provide growth opportunities for the residents of Appalachia – the same benefits afforded the rest of the nation through the construction of the interstate highway system, which largely bypassed Appalachia because of the high cost of building roads through the Region's mountainous terrain. The ADHS, a 3,090-mile system of modern highway corridors that replaces a network of worn, winding two-lane roads, was designed to generate economic development in previously isolated areas, supplement the interstate system, and provide access to areas within the Region as well as to markets in the rest of the nation." Of the 3,090 miles of highway included in the ADHS, 2,632.5 miles have been constructed or are under construction as of September 2005.

The Local Development Districts Program established multi-county Local Development Districts (LDDs), which provide planning and development programs, assist with providing local services, promote public-private partnerships in business development, and provide job training and other support services. The Research and Technical Assistance Program conducts research and evaluation studies that include socioeconomic trends analysis, program evaluations, economic impact analysis, and economic and transportation modeling. Through this program, the ARC funds staff as well as outside, independent researchers to measure the performance of ARC programs and grants.

The ARC has a long history of both trying to predict the economic impacts of its investments and evaluating the performance of its programs and expenditures. Predictive studies are most often employed to identify how investments in infrastructure will help to further the Commission's economic development goals of job creation and retention, business expansion and retention, economic diversification, and raising the incomes of the population. These studies, often conducted by outside consultants, use econometric modeling techniques, site analysis, business and public sector interviews, transportation models, and extensive transportation and economic data (both published national and regional data, and data collected through surveys, site visits and interviews) to estimate future impacts.

The ARC uses evaluative economic impact studies to validate its past investment expenditures, help target future expenditures to programs that prove most effective in supporting the Commission's mission, and revise programs to better accomplish its goals. The Commission conducts an annual in-house performance review of its four program categories as required by the Government Performance and Results Act of 1993 (GPRA). The GPRA requires that the ARC define performance measures and goals for all of its major operations at the start of each fiscal year. At the end of each year, using the measures defined by the ARC, the Commission evaluates the degree to which the programs achieved their goals.

Further, *"each year one of the Commission's strategic goals is selected for review and analysis. These reviews are conducted by qualified independent, third-party organizations (e.g., private firms, universities) whose work is conducted under professional standards to ensure independence, relevance, and quality. Evaluations focus on the extent to which projects have achieved, or contribute to the achievement of, their objectives. Particular emphasis is placed on assessing the utility and validity of the output and outcome measures."* [64]

Both the annual agency performance review and these in-depth reviews of individual programs are used by the ARC staff to improve its program and select projects for funding, and by the federal government to determine future funding levels for the Commission.

Finally, considerable independent academic studies have been conducted to evaluate the economic impacts of ARC programs. The impact analyses range from predictive studies of proposed or current ARC programs to evaluative studies that measure the past performance of ARC programs.

The ARC stands out as an agency that has conducted a large number of both predictive economic impact studies and program evaluations based on economic development performance indicators, including several monetized measures. The wide range of predictive studies reflect that while ARC's overarching mandate is economic development, much of its economic development program expenditures have focused on infrastructure investment, with a large share of those expenditures on the Appalachian Development Highway System. The ARC often conducts predictive economic impact studies to justify large outlays of public dollars for these projects. The ARC's history of economic performance evaluations reflects the ongoing demand by the federal government as well as critics of the Commission that the ARC document the results of its program to justify its continued funding.

History of Monetization

When the Appalachian Regional Commission was created in 1965, it was one of only two federally-supported regional agencies in the country. (The other was the Tennessee Valley Authority.) With large sums of federal dollars targeted to economic development activities in a single region, the Commission and its performance faced tough scrutiny and ongoing criticism from its inception. Evaluations of the Commission's ability to meet program goals started as early as 1968[65], and have continued up through today. The economic development focus of the Commission has resulted in the use of economic measures of performance, including:

- Number of jobs created or retained;
- Jobs created per dollar of public investment (as well as per ARC dollar invested);
- Changes in the poverty rate over time, including comparisons to changes in poverty rate for the nation as a whole; and
- Changes in personal income and per capita income over time, including comparisons to similar changes for the nation as a whole.

These performance measures have traditionally been used as measures for the ARC's first two overarching goals: increasing job opportunities and income, and strengthening the capacity of the region's population to participate in new economic opportunities. For the purpose of its annual reviews, the performance of its infrastructure programs has been measured in terms of number of households served and the highway program in terms of number of miles of highway completed or under construction. (The use of number of households served reflects the emphasis of the infrastructure program on sewer and water projects.)

More recent in-depth impact studies have used a range of performance measures to assess the past performance or projected future performance of both the Commission's infrastructure program and the ADHS (the Commission's third and fourth goals). These have included benefit/cost ratios, internal rate of return on investment, and net present value related to the transportation efficiency benefits, as well as measures of the economic development impacts of the investments in terms of jobs, income (wages), value added, population, and taxes. These studies take economic impact analyses a step further than most economic analyses by also measuring how well the ARC's funds are leveraged. Measures include dollars of public investment/job created, ratio of ARC dollars of investment to private sector investment generated by projects, and the ratio of ARC dollars invested to other public funds used on a given project.

The ARC's economic development mission, both in terms of raising the economic conditions in the counties within its jurisdiction and helping the region as a whole compete in the global marketplace, has further focused the Commission's economic impact analyses on three categories of impacts:

- Economic efficiencies, such as reduced business costs associated with decreases in travel times and operating costs, which make the region more attractive as a business location;
- The distribution of impacts within the region, with particular focus on how well the Commission's programs are helping improve economic conditions in the most distressed counties in the region, and
- Impacts attributable to improved access to markets within the region, in the broader United States, and globally.

While this focus has not necessarily led to the monetization of impacts not previously monetized, it has led to new approaches to using monetary impacts for evaluating past and future investments. The following section discusses specific ARC studies to illustrate how the Commission uses monetary measures to evaluate the impact of its investment in these three impact categories. Table 5-4 lists the economic development impacts monetized in these studies.

Table 5-4: Economic Development Impacts Monetized in ARC Studies

Measure	Units
Jobs	- Jobs created per dollar of public investment - Jobs created and retained per dollar of public investment
Poverty	- Change in number of residents living under the poverty level - Change in poverty rate in region compared to other comparable regions and the nation as a whole
Leveraging of ARC investment	- Ratio of private dollars invested to ARC dollars invested - Ratio of private dollars invested to all public dollars invested
Income, wages	- Dollar value of change in personal income - Ratio of personal income created to dollars of public investment - Dollar value of change in per capita income - Dollar value of change in personal disposable income
Transportation Efficiencies	- Dollar value of travel times savings - Dollar value of safety benefits - Dollar value of operating costs savings
Value added, gross regional product	- Dollar value of change in gross regional product - Dollar value of change in value added
Taxes	- Change in property taxes - Change in sales taxes - Change in income taxes

Measuring the Economic Development Impacts of Efficiencies and Access

In 1998, the ARC commissioned an analysis of the economic impacts of the Appalachian Development Highway System. Already existing tools and measures were used to evaluate the impacts of the highway investment. The researchers used the Highway Performance Monitoring System (HPMS) to calculate travel time savings associated with the investment, and the Highway Economic Requirements System (HERS) to translate these time savings into monetary values. HPMS was also used to calculate vehicle operating cost savings and the consultants used available FHWA highway statistics to calculate safety benefits. These three benefits together quantify the total travel efficiency benefits of the highway. The study includes a benefit/cost (B/C) analysis that compares the total travel efficiencies of the highway investment with the construction and maintenance costs of the system, including measures of the net present value and internal rate of return of the investment, as is common practice.

To measure the economic impacts of the highway, the REMI regional economic forecasting model was used. Inputs to the economic model included both the travel efficiencies derived using HPMS and HERS, which translate into a competitive advantage for the region as a business location, and estimates of new spending in the region resulting from expansion of roadside services and increased tourism. The estimates of new spending and tourism were derived from a separate business attraction analysis that examined the existing economic base of the region and how the investment would provide better access to markets outside the region. It relied on site analyses, business interviews, and surveys of travelers to the region. The model output provides measures of the economic impacts in terms of jobs created, value added, wages, and population.

While the study did not employ new measures or modeling tools to estimate the impacts of the ADHS, it did include a unique perspective which required modification to the economic model, and important output that could be used to more accurately calibrate the economic model. Unlike studies completed before a highway investment to justify the investment based on what its impacts might be, the study focuses on measuring the economic changes that have occurred in the region due to investment in the ADHS to date, and compares them to an estimate of what would have occurred had the highway investment not occurred. Then these known impacts are forecast forward to estimate the economic impacts of the highway investment into the future.

This approach allows for much more certainty in estimating impacts because:

- *"The actual construction costs are known; they need not be estimated.*
- *The highway locations and alignments are known; they need not be planned.*
- *The highways are open to traffic and the traffic volumes are known; traffic need not be estimated."*[66]

Since the economic model was designed to forecast the future based on past economic trends, the challenge in this study was to adjust the model to predict what would have happened in the past without the highway investment.

This study approach was an important advancement in economic impact analysis of highway investments by public agencies for two reasons. First, most federal and state departments of transportation only conduct predictive studies to inform an investment decision. Evaluative studies are not conducted after the investment to verify the results of the predictive analysis. Thus, there is never an assessment of the accuracy of the predictive modeling. Using the methodology employed in this study, which measures the historical impact of the investment, ARC was able to evaluate if the highway investment is meeting its intended goals. This information was used to help set more accurate goals for future investments in additional highway segments, and the results of the historical study used to inform and adjust the inputs to any economic models used to predict future highway investments. Second, it showed how the results of an historical study can be used to better estimate the long-term impacts of an already constructed highway, providing useful information for planning additional transportation improvements, as well as for services to support expected economic impacts (such as sewer and water infrastructure, business parks, etc.).

During the past several years, ARC has expanded its research of the economic impacts of transportation infrastructure investments to look at the potential benefits that could accrue to the region by expanding intermodal facilities within Appalachia. A four-part study published in 2004 sets the stage for understanding the role of intermodal transportation in enhancing the region's role in the global economy.[67] These studies identify the potential to enhance economic development in the region by expanding opportunities for transporting both industry inputs and outputs via an intermodal transportation network. The studies:

- calculate the current global competitive position of six key Appalachian industries,
- identify how projected increases in freight flows within the region will begin to choke the existing highway system and how the investments in the Appalachian Development Highway System and key intermodal facilities (including rail systems, airports, inland ports, and water transportation) can alleviate transportation bottlenecks and position the region to better meet the future global transportation needs of the region's industries,
- evaluate how six case study intermodal facilities can help reduce the cost of doing business in the region, and
- begin to estimate how three investments in intermodal facilities can lead to travel efficiencies within the region, translating into job creation, increases in gross regional product (GRP), and increases in personal disposable income.

This series of studies is important to include in this case study not because they monetize the economic development impacts of travel efficiencies (in terms of increases in GRP and personal disposable income), but because they recognize that the emerging global economy has led to an increased dependence on intermodal transportation facilities to efficiently transport goods, thus making it no longer sufficient to look at the transportation efficiencies provided by individual transportation investments in isolation. Instead, future impact evaluations will need to look at how investments in one mode lead to transportation efficiencies not only on the facility itself, but also through the intermodal connections facilitated by the investment. Further, these studies note that the improved access provided by intermodal connections will have additional economic development impacts, which can be monetized in a number of ways (e.g., wages, GRP, value added) through the use of econometric models.

In addition to its efforts to monetize the economic impacts of the region's transportation system, the ARC has also commissioned studies to evaluate the impacts of its infrastructure programs, including a 2000 study that assessed the economic impacts of 99 ARC infrastructure projects completed between 1990 and

1997. The projects evaluated represented four categories of ARC programs: access roads, industrial parks, business incubators, and water/sewer projects. (Eighty-seven of the projects were classified as economic development projects and 12 were classified as sewer and water projects for residential areas).)

The goal of this research was to, 1) assist the ARC in its internal evaluation of project performance and identification of areas for improvement, and 2) facilitate the public understanding of the ARC's impact.

The project evaluation focuses on key performance measurements and outcomes:

- "the number of jobs projected and actually created or retained after project completion;
- the leveraging rates for other project-related funds, including state, local, other federal and private investment;
- a determination of the agency's relative funding contribution;
- a calculation of the job creation rate attributable to ARC's investment once the impact of other funds is considered;
- the diversification effects of the projects on the local economic base;
- the indirect economic effects attributable to the project;
- the impacts on the local tax base resulting from the projects;
- an impact/cost analysis of the projects; and
- quality-of-life improvements provided to residential households served by the water and sewer projects."[68]

Six of these evaluation measures involved a monetary assessment of the impact of the infrastructure program.

The methodology for collecting data for this analysis and evaluating the impacts was comparable to the methods used for the prior research. The research was led by a team of economists and economic development professionals experienced in conducting impact analysis of public investments. The research team relied on both published national and regional data, as well as data collected through interviews with economic development professionals and businesses in the study area. Traditional economic analysis tools, such as location quotients, were used to assess baseline conditions. To identify the indirect and induced economic impacts of the investments, the researchers used the IMPLAN economic model, which uses industry multipliers to calculate employment and personal income.

A unique feature of this study was the benefit/cost ratios developed to measure the economic benefit of these projects. From an economic development standpoint, the outputs of interest were number of jobs created, level of private investment stimulated, and the increases in personal income realized. Therefore, the performance measured used for the B/C analysis were:

- Public cost per job created

- Private sector investment leverage (ratio of private investment per public dollar), and
- Personal income created per public dollar spent.

These ratios all provide a monetary measure of the economic development impacts of the ARC's infrastructure program. The ARC can use these measures to both evaluate the success of the program and inform future spending. ARC is currently updating this infrastructure study to evaluate more recent infrastructure investments.

Monetizing Distributive Impacts of the ARC

Throughout ARC's history, independent researchers have tried to evaluate the socioeconomic impacts of the Commission, undertaking studies to compare growth in income, poverty levels, population, infant mortality, education levels, per capita income, and other factors to national growth rates. The risk with such studies, however, is that the findings are not applicable outside of Appalachia because of the unique economic conditions within the region.

One 1995 study attempts to address this issue using a comparison group methodology that relies on identifying for each county in Appalachia, its closest "twin" county outside of the region.[69] Twins were selected based on counties had pre-1965 populations, per capita incomes, access to interstates, and population densities comparable to the Appalachian counties to which they were matched. Differences in growth rates between ARC counties and their twins are assumed to represent "what would have happened in Appalachia without the ARC," i.e., without ARC programs.

Using regression analysis, the researchers compared growth in 20 variables, including income, population and per capita income between Appalachian counties and their twin from 1969 through 1991. They found that the counties in Appalachia "averaged 48 percent more growth in income, 5 percent more in population, and 17 percent more in per capita income"[70] over the study period, indicating that the ARC's coordinated investment strategy has paid off. Although the authors were unable econometrically to establish a robust relationship between ARC programs (growth centers, distressed counties, and highway investments) and economic outcomes in Appalachian counties, their use of "twin" counties for comparison was viewed as a major step forward in isolating the impacts of the ARC's programs. The Commission has recently commissioned an update of the "twin" counties study. Preliminary results from the updated study suggest that with improvements in measurements of highway investments, it is possible to establish a statistical relationship between highway investments and economic growth.[71]

This type of evaluative control study provides important information for assessing the real impacts of a public investment. However, it requires significant data collection and statistical modeling expertise. Data collection across broad geographic areas and time spans can be difficult, as different jurisdictions collect data at varying levels of detail, the types of data collected change over time, and definitions for specific variables may vary by jurisdiction and also change over time. Therefore, while this type of assessment is important to an agency such as the ARC, which must continually demonstrate the value of its programs, it is less clear when such an analysis would make sense for a transportation agency.

Technical Guidance that Emerges from Case Study

Data – The data requirements for estimating economic development impacts are extensive. The ARC relied on both published sources and primary sources. Published data on poverty levels and personal income are available from both state and federal sources. Caution is necessary when combining data from different sources, as reporting requirements and definitions may vary among sources. Further, over time, reporting requirements and definitions may change in a single source, making it difficult to do comparative analysis or measure change over time. Researchers need to be aware of these potential discrepancies and make appropriate adjustments.

Economic development impact analyses also rely on significant primary data collection. Data was collected through a combination of on-site and telephone interviews with businesses and economic development professionals, as well as through surveys. Oftentimes, interviewees and survey respondents find it difficult to place numerical values on anticipated impacts from an investment, or to confidently attribute changes in jobs, income, or productivity to an infrastructure or program investment. To extract accurate primary data, a planner or economist with an understanding of the economic relationships being investigated should design the interview guides and surveys used to collect such data.

Analytical Modeling – Measuring actual or predicted economic impacts usually involves the use of some form of regional economic model. These tools are constructed to reflect how changes in public policies or investments affect interindustry relationships and, ultimately, output, jobs and income. These tools have been employed by numerous public agencies (including several transportation agencies) to measure the expected impacts of alternative infrastructure investments. Some agencies have purchased the econometric tools for in-house use, and have hired staff economists to develop inputs and run the models. This approach means economic impact analyses can be conducted for a variety of projects on an ongoing basis. However, the models do need to be updated to reflect current information on a regular basis. Some agencies employ these models less frequently, and hire outside consultants and economists to collect data, run the models, and interpret the results. In these cases, the economic modeling is done on a case by case basis, typically when economic development impact will play a major part in investment decision-making.

Conclusions

The ARC's unique status as one of only two federally-funded regional planning agencies with an economic development mission elevates the importance of using monetized economic development measures for evaluating investments and performance. Monetary measures such as changes in per capita income, gross regional product, and value added; public dollars leveraged by private investment; and the cost/job of ARC programs are used on an on-going basis to:

- justify future federal earmarks for the Commission,
- improve program delivery,
- target future investments to projects likely to have the biggest impact on realizing the economic development mission of the organization, and
- educate the public about the success of the Commission's work.

The ARC's mandate to improve socioeconomic conditions in the Appalachian region dictates the monetization of economic development measures for program evaluation and predictive impact analysis.

These economic development performance measures could provide new opportunities for transportation agencies to more fully document the monetary impacts of major investments. When transportation investments are being pursued in an effort to stimulate economic growth, these measures can help clarify how the project will impact the economy. Additionally, in cases when alternative transportation investments are expected to have different impacts on the economy, these measures can be used to document the differences. These economic development measures can also help transportation agencies develop a fuller accounting of the total monetary impacts of investments With the growing recognition that intermodal connections improve transportation efficiencies and economic growth potential beyond a single transportation infrastructure investment, use of monetized economic development performance measures could become more useful to and important in project evaluations.

5.4 Case Study: Florida Dept. of Transportation

Introduction

Organization - The Florida Department of Transportation (FDOT) has a long history of focusing on performance measures and has been regarded as a national leader in this area for several years. Several reports currently are published annually to report on the Department's progress in meeting objectives related to safety, mobility, preservation, the environment, budget allocation and spending, customer and employee satisfaction and on-time project delivery both at the system and program levels. Among those reports are the Performance and Production Review Report, Business Model Report, and Short-Range Component and Annual Performance Report. The Performance and Production Review monitors the Department's budget allocation strategies and identifies program areas within FDOT that need improvement. The Business Model Report reports on the Department's progress in improving customer and employee satisfaction, system safety, and project construction time and cost. Finally, the Short-Range Component reports on system performance and guides the Department in developing both short and longer-term policies related to mobility, safety, preservation, the environment and quality of life, and sustainable funding.

Case Study Selection – The particular interest in the case study of Florida DOT comes from its new and evolving efforts to monetize performance measures across multi-modal systems. The case study traces the evolution of these efforts from an initial economic development of highway systems to a broader Strategic Intermodal System analysis.

Agency Background.

New legislation and the restructuring of investment policies within FDOT are affecting how the Department measures performance. The development and adoption of the Strategic Intermodal System (SIS) in 2005 -- a statewide network of high-priority transportation facilities, including the State's largest and most significant commercial service airports, spaceport, deepwater seaports, freight rail terminals, passenger rail and intercity bus terminals, rail corridors, waterways and highways – redefined the State's role by focusing limited State resources on those facilities that promote statewide and interregional mobility and enhance Florida's economy and opened the door to increased investments in non-highway modes. The 2025 Florida Transportation Plan strengthened the policy framework for looking at transportation in the context of broader economic, community, and environmental goals, and enhanced the emphasis on regional planning. The 2005 Growth Management Bill strengthened the need to coordinate transportation and land use decisions, especially at the regional level, and created new funding programs such as the Transportation Regional Incentive Program (TRIP) to better meet the increasing demand for regional travel and commerce.

With these newly enacted policies and the continued shortfall in revenues, FDOT is faced with the increasing need to consider a full range of issues and impacts in making investment decisions. More recently, FDOT began working toward the development of measurement tools to help evaluate and guide transportation investments in the State as well as track FDOT's progress in achieving the goals and objectives that are set forth in the Florida Transportation Plan (FTP).

In 2003, the Department completed a macroeconomic impact analysis to assess the impact of its proposed Work Program transportation investment plan on Florida's citizens and businesses. The analysis was crucial for examining the linkage between transportation investments in both highway and non-highway modes and the State's economy. An updated version of this analysis was recently completed in 2006 and FDOT is currently contemplating developing additional economic analysis tools to be used for evaluating the benefits from specific projects or groups of projects.

FDOT also is in the initial phase of developing a project investment decision tool entitled the Strategic Intermodal System Investment Tool, or SIT tool. This tool will be crucial for prioritizing projects of statewide significance, i.e. on the Strategic Intermodal System. Although not all measures are expressed in dollar terms, the SIT tool will help prioritize projects across all modes by weighting the impact of each project on five major goal areas including safety and security, system preservation, mobility, economic competitiveness, and quality of life.

Moreover, FDOT recently has began working toward the development of a detailed FTP Performance Measures Framework to analyze and report on the performance of the State's transportation system as well as the effectiveness of the Department's programs in accomplishing statewide goals.

History of Monetization

In response to a legislative mandate to analyze the macroeconomic implications of transportation investments and to provide an understanding about how transportation impacts Florida's competitive position, FDOT developed a macroeconomic analysis methodology to evaluate the long-term economic benefits of the Department's Work Program. These benefits include increases in personal income to Florida residents, employment, and Gross State Product (i.e., the total value of goods and services produced). The key objective of the legislative requirement is to ensure 'that the state has a clear understanding of the economic consequences of transportation investments… [and to] develop a macroeconomic analysis of the linkages between transportation investment and economic performance" at the state and district levels. The legislation specifically requires the analysis to assess 1) the state's and district's economic performance relative to the competition; 2) the business environment as viewed from the perspective of companies evaluating Florida as a place to do business; and 3) the state's capacity to sustain long-term growth.

The macroeconomic model developed by the Department directly analyzes the impact of Work Program investments on travel conditions in the State, including travel time, vehicle-operating costs, and economic costs associated with safety. The model quantifies the benefits from Work Program investments in highway, transit, seaports and rail projects that reduce transportation costs, and then translates those benefits into cost savings for the State's businesses. The reduced cost of doing business in Florida allows businesses to be more competitive and increase their market share. Direct user benefits include travel time savings, reduction in vehicle operating costs, and reduction in the number of accidents. Secondary business benefits associated with long-term changes in productivity that are expressed in this model are increased output (sales), hiring additional workers – a benefit that is seldom measured or reported in the United States, and ultimately increasing the personal income of Florida's residents.

The macroeconomic model represents a significant milestone in evaluating the economic benefits of investments in Florida's transportation system and guiding future transportation investment policies and legislation. In 2006, macroeconomic business benefits and personal travel benefits yielded $5.6 worth of economic benefits for every $1.00 invested in the Work Program for highway, rail, seaports, and transit in Florida; a 1.8 percent increase in benefits from 2003. The model however is limited to overall statewide investment policies, does not capture specific investment impacts at the project, system, or modal level, and only accounts for the monetary value of economic competitiveness.

With the increasing number of modes and hence projects that are currently eligible for funding through the SIS program, a new methodology for determining project priority is being developed for the Strategic Intermodal System by FDOT and a Modal Outreach Team made up of various transportation experts. This methodology incorporates project priority criteria that are currently used by operators of Florida's highways, seaports, airports and railroads.

The Strategic Intermodal System Investment Tool will replace the existing Florida Intestate Highway System (FIHS) Tool and help guide the Department's project investment strategies by identifying those projects that are most likely to support SIS policies and goals. Unlike the FIHS tool which only prioritizes and ranks highway projects, the new SIT tool will help prioritize projects across all modes by weighting the impact of each project with respect to five categories of prioritization criteria, corresponding to the SIS goals; namely safety and security, system preservation, mobility, economic competitiveness, and quality of life. The SIT tool is expected to include monetized measures related to user benefits (mobility) and benefit-cost ratios (economic competitiveness). Projects will be weighted against all goals equally. Each goal includes a set of measures with different weighting factors. The weighting factors can be changed over time if determined necessary. These factors were developed with the assistance of all modal partners within the Department. The SIT tool is anticipated to be implemented in Fiscal Year 2007. FDOT anticipates working with system operators, the Districts, and local governments and partners on collecting data to support the project prioritization effort.

More recently and in an effort to move from program or SIS-specific to a broader system-level analysis of Florida's transportation system including SIS, regional, and more local projects, FDOT currently is in the early stages of developing a Performance Measures Framework to help develop coordinated measures to track the five goals: safety and security, quality of life and environmental stewardship, maintenance and preservation, mobility and economic competitiveness, and sustainable funding that were identified in the 2025 Florida Transportation Plan (FTP).

Measures expressed in dollar terms currently are limited to statewide and regional macroeconomic benefit measures including changes in personal income, Gross State Product from FDOT's Work Program investments in facilities that are of statewide significance, i.e. designated to the Strategic Intermodal System (SIS) and Regional State Product anticipated from Work Program investments in facilities of regional significance Monetary measures from other goal areas have yet to be developed, but could be considered in future updates of the Framework. These could potentially include measures on cost of delay, fuel costs, and the environment.

FDOT recently has completed a draft of the conceptual phase of the Framework. Many challenges lie ahead however, in terms of data collection according to DOT staff particularly on the issues related to data availability and reliability, as well as the cost of purchasing new datasets on a regular basis for non-highway modes.

Technical Guidance that Emerges from the Cast Study

For the Macroeconomic Impact Study, the Highway Economic Requirements Systems (HERS) and National Bridge Investment Analysis (NBIAS) were used to estimate direct transportation benefits (travel time, vehicle-operating costs, and accident costs) of highway and bridge investments that add capacity and/or preserve existing facilities. Various statistical modeling and interview techniques were applied to estimate transit and rail ridership effects, port capacity enhancements (e.g. increased tonnage, cruise passengers, Twenty-Foot Equivalent Units (TEUs)), and freight rail benefits. Data inputs and methodologies of a freight rail benefit/cost tool used by the FDOT Rail Office were applied to measure diversion from truck to rail and reductions in shipping.

The REMI economic simulation model was used in the analysis to account for the expansion and attraction of firms due to a reduced cost of doing business from transportation investments. The economic model estimated business expansions and attractions, as well as an influx of workers who would move to the state to take advantage of new employment opportunities and the improved business environment. The economic benefits of increasing seaport capacity were developed using the Maritime Administration (MARAD) economic impact kit.

The economic model also estimated the full economic impact of the reduced cost of doing business in Florida resulting from Work Program investments that reduce transportation costs over time (25 years) in a dynamic fashion as changes to the economy affect prices, wages, and other competitiveness factors.

It is recognized that the model only estimates the economic benefits from the State's investment in Florida's transportation system and does not currently account for investments made by all levels of governments and the private sector. FDOT currently is exploring the possibility of developing the necessary tool to allow for the flexibility of estimating the economic benefits from transportation investments internally and on a more regular basis.

Role of Monetization in Organizational Decision-Making

In light of recently adopted policies and limited resources, monetized measures are anticipated to play an increasingly larger role in the transportation planning and investment processes in Florida. New initiatives such as the Future Corridor Initiative aimed at identifying transportation corridors that will be significantly improved or developed over the next future years increasingly are relying on benefic-cost measures to help guide the decisions related to project location and prioritization. As monetized measures continue to be developed to support the FTP Goals, these would become more effective at guiding the Department and its partners toward more informed and effective policy choices and investment decisions related to SIS, regional, and local facilities and better measure progress towards achieving results at both the policy and system levels.

Conclusions

With mounting pressure resulting from new and revised investment and planning policies, Florida is currently investigating new and innovative ways to measure performance to ensure that available resources are allocated appropriately. Several new and recent initiatives including the future corridors and regional visioning planning initiatives are examples of policy-driven efforts to implement the 2025 Florida Transportation Plan that are going to yield additional needs for performance measures. Early indication is that the proposed criteria for identifying new corridors will include user benefits, economic benefits, and benefic cost ratios that may potentially include environmental and land use impact components. Similarly, the process related to the evaluation of regional investments may include monetized measures to identify potential projects. The FTP Performance Measures Framework could be expanded to support these ongoing initiatives and investigate a wider range of transportation impacts using monetary measures as appropriate and building upon existing work on the macroeconomic impact study and ongoing work on the SIT tool. Additional tools can be examined as well including the HERS transportation model and updated economic models, the Efficient Transportation Decision Making (ETDM) process which primarily investigates the impacts of transportation investments on the environment and communities, and the Florida Standard Urban Transportation Model Structure (FSUTMS) which predicts the effects of various policies, programs, and projects on highway and transit facilities.

5.5 Case Study: Montana Dept. of Transportation

Introduction

Organization – Montana Department of Transportation (MDT) has been at the forefront of multimodal statewide planning and prioritization, incorporating economic development objectives. In 2002, MDT issued its "*TranPlan21*" multimodal statewide plan. That plan included a major economic development element. [72] In 2004, MDT issued its *Strategic Business Plan*, which combines transportation performance measures and organizational performance measures that together represent the agency's twelve strategic initiatives. [73] These goals include enhancement of mobility, delivery of cost effective transportation, reduction in accidents and implementation of the TranPlan21 economic objectives.

All of these activities complement MDT's annual *Performance Programming Process (P3)*. That process allocates 70% of the agency's capital construction program among districts, highway systems and types of work based on predicted performance. Performance predictions are generated by management systems. All projects that enter the construction program must be consistent with the treatment strategies in this analysis and the adopted funding allocation plan. P3 has focused on four performance evaluation criteria: congestion relief, safety, bridge management, and pavement management. However, economic development goals were placed at the front of public attention with the Montana *Highway Reconfiguration Study* which sought to assess how appropriate reconfiguration of the statewide highway system could best support statewide economic development.

Case Study Selection – Montana was selected as a case study specifically because of the Highway Economic Analysis Tool that was developed for MDT and then implemented by the agency to evaluate and monetize the economic benefits of alternative highway improvement and reconfiguration projects. The features of this tool and the way in which it is being used by MDT illustrate issues and opportunities in the use of economic development considerations for highway decision-making. This case study also discusses an antecedent tool that was developed earlier by Indiana DOT, and the nature of more recent improvements in the Montana version.

History of Monetization

While MDT has had a history of using performance measures for both long-run strategic business planning and for the short-run P3 process, it relied largely on engineering-based, non-monetized, performance measures as part of its decision-making process. These performance measures included physical characteristics such as pavement quality and bridge condition, comparing current and future conditions. Only cost was monetized. However, the agency adopted monetary measures of economic development impacts following initiation of the statewide highway reconfiguration study in 2001.

That year, the new Governor of Montana directed the MDT to conduct a study examining the economic impact of reconfiguring the State's system of highways. The governor noted that "In my campaign for governor, I indicated that the development of economic corridors was a critical component of a visionary, long-term economic stimulus effort. The safe and efficient movement of goods and services on four-lane highways will bring more economic opportunities to communities throughout Montana, which is why I have directed the Department to study the exciting possibility for highway expansion throughout the State. … We are making economic growth our priority and we must ensure that all areas of Montana are considered for highway construction dollars"[74] .

The resulting study was initiated with three goals: [75]

- Identify which transportation investments will benefit specific Montana industries;
- Provide MDT with an analytical toolbox to evaluate economic development impacts of transportation improvements; and
- Apply the analytical toolbox to quantify the economic impacts of transportation improvement scenarios as part of MDT's planning process.

The toolbox developed to accomplish these objectives became known as the Highway Economic Analysis Tool (HEAT). The tool was developed to accomplish these objectives by providing a much more detailed understanding of the relationship between specific changes in highway capacity and economic development. It provides the data as well as models to quantify that relationship and estimates the economic impacts (including monetized factors) of a range of highway improvements within both a constrained and unconstrained fiscal environment. Three categories of monetary benefits are incorporated into HEAT: 1) traditional user benefit metrics such as travel time savings and reduction in operating costs; 2) economic development impacts such as gross state product (GSP) and personal income; and 3) total benefits (economic development and non-business user benefits) that are used as part of a benefit/cost analysis.

Evolution of HEAT from Prior Indiana DOT Efforts - While Montana's Highway Economic Analysis Tool (HEAT) is a system to monetize the economic development benefits associated with transportation improvements, it represents the evolution of a tool developed a decade earlier for the Indiana Department of Transportation (Major Corridor Investment Benefits Analysis System or "MCIBAS"). HEAT, like MCIBAS, monetizes the value of the benefits that accrue to the state's businesses and may be used to evaluate transportation programs, corridor plans, potential projects and alternative alignments. The measurement of economic development impacts expands the options available to transportation agencies to evaluate (or demonstrate) the benefits of transportation improvements. HEAT and MCIBAS applications are currently limited to highway improvements (not other modes).

The unified structure of HEAT makes it relatively easier to use than the earlier MCIBAS, thus making it a more accessible tool that can be more readily applied to a range of uses. While MCIBAS is comprised of a series of separate modules and requires data generated by one module to be manually transferred to the next before yielding results, HEAT integrates multiple, inter-connected modules on a single GIS platform. The single platform eases the use of the newer system for the Montana Department of Transportation.

While HEAT's more integrated operational structure offers ease of use, it essentially performs similar functions as MCIBAS. The origins of Indiana's MCIBAS model resulted from INDOT's interest to evaluate the economic development impacts of roadway corridor improvements in a benefit/cost framework that would allow transportation projects from different areas within the state to be compared. The development of the MCIBAS system allowed INDOT to measure these impacts by monetizing user benefits and applying business and tourism attraction models (based on accessibility measures and industry competitiveness) to monetize the benefits accruing to businesses. A modified version of MCIBAS has been used on a statewide basis to assess INDOT's Long Range Plan, using similar analytical modules to generate monetized results.

With the HEAT model, MDT obtained a tool to evaluate both the economic development and user benefits of capacity expanding programs in a benefit/cost framework. MDT is still determining how best to use the model to help make program and project level decisions. Recently, MDT determined the monetary benefits of system preservation. This was achieved by simulating MDT's five-year program of pavement projects and then using HERS (Highway Economic Requirements System) to estimate the operating cost and travel time effects of having improved pavement quality. This allows for a comparison of capacity and preservation investments in monetary terms. A next step for HEAT is to increase its use as a tool to prioritize proposed projects and corridors.

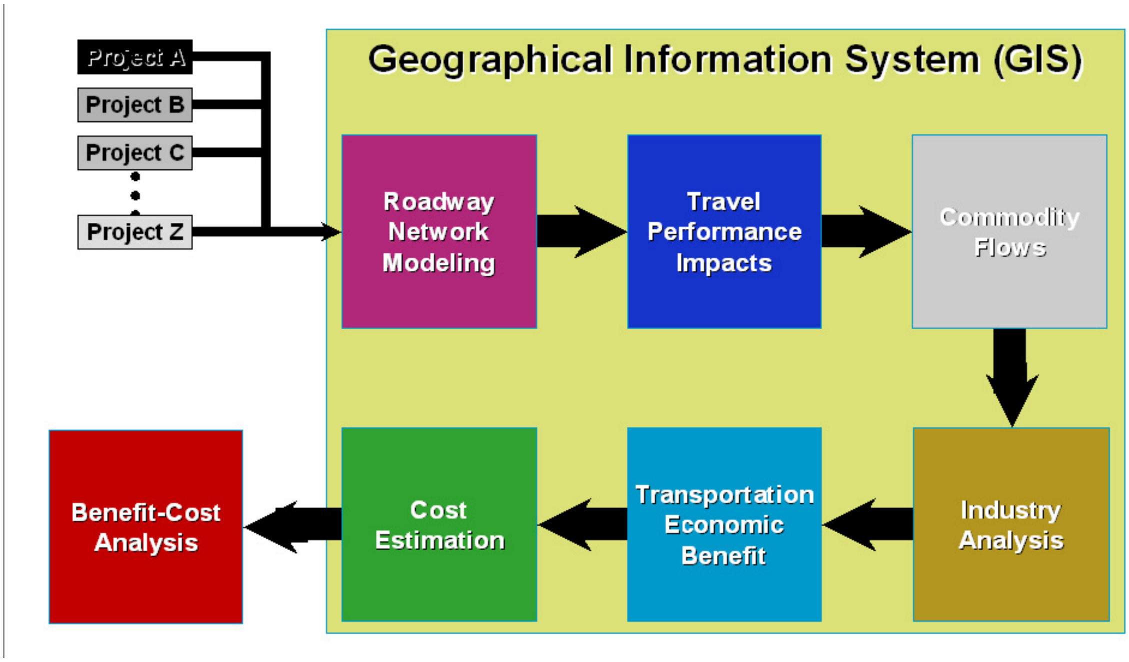
Strong state support has been crucial to the development and application of HEAT. The Governor of Montana budgeted $1 million to assess economic effects of four-laning highways which allowed development of the tool. Following the initial completion of the HEAT model, MDT hired an economic geographer to run the tool and has dedicated a modest budget to run it.

Technical Guidance that Emerges from Case Study

The technical advances of HEAT are reflected in the structure of the model and include: (1) the incorporation of GIS programs to allow large amounts of data to be managed and permit users to run multiple programs within a single platform (i.e., HEAT can run Excel and REMI from GIS); (2) calculations of non-recurrent delay in addition to average travel performance; and (3) the application of different estimates for the value of time (for trucks) based on commodity (e.g., the trip table distinguishes between six truck categories reflecting different commodities).

HEAT has been applied by MDT for program evaluation and as a communications tool. It has the capability, but thus far has not been used, to compare the benefits of individual projects. It has been used to estimate the benefits of long-range prospective corridor improvements. In addition to benefit/cost metrics (that use GSP as a benefit), it also measures jobs by industry, income and business output at the statewide level and for five MDT districts.

Figure 5-1. HEAT Analytical Modules



HEAT incorporates a range of quantitative metrics to provide a means for evaluating the economic benefits of highway capacity improvements (see diagram in Figure 1). All of the following analytical steps are run within the HEAT GIS program.

- *Statewide roadway network model* - The HEAT analysis begins with the definition of a highway improvement project or group of projects (or plan). These projects are coded into the statewide roadway network model, developed as part of a GIS framework, to determine the traffic volumes, speeds, safety, and cost factors affected by the project(s).

- *Travel performance impacts* - Travel performance impacts include traditional monetary metrics such as travel time savings and reductions in operating costs as well as measures of accessibility to markets (e.g., improvements in access to labor within a one-hour drive) and reliability (e.g., reduction in non-recurrent delay). This process takes into account the differences in the value of time for trucks depending on the types of commodities being carried.

- *Industry analysis* - This module includes the estimation of three types of direct economic benefits: (1) reductions in the cost of doing business based on the size of each industry and its dependence on trucking; (2) net business attraction/retention based on market accessibility; and (3) visitor spending effects on the economy (this component of the model is only applied if an improvement is expected to enhance access to more tourism-intensive areas).

- *Transportation economic benefits* - The industry impacts (generated from the industry analysis) are used as inputs into a regional economic simulation model of the Montana economy. HEAT incorporates a five-region economic impact model developed by REMI to estimate total impacts on gross state product, employment, and personal income.

- *Cost estimation* - HEAT also includes a cost estimation tool that provides a consistent method for estimating the capital and operating costs of highway improvements throughout the state.

- *Benefit-cost analysis* - In the last step, HEAT includes a benefit-cost analysis module to compare economic benefits and costs. The estimate of total benefits includes both traditional user benefits (i.e., value of non-business related travel efficiencies) and business/tourist attraction on the broader statewide economy.

In order to run HEAT successfully, several databases must be developed to be used as inputs and a staff with specialized technical skills in economics is required. Data and organizational requirements include the following:

Data requirements – HEAT relies on considerable volumes of travel model, commodity flow, and industry data. For this reason, the availability of current and easily updated data is important, including actual travel survey data to assist with traffic counts and origin-destination patterns. A travel demand model, commodity flow data (optional), a user benefits module including parameters, and county-by-county industry employment levels provide HEAT with the base data needed for the model to operate. In order to conduct consistent analyses of highway projects across a state or region, it is very helpful to have a functioning, current travel demand model (the model in Montana is a simplified model, not a traditional four-step model). For rural projects, it is essential to have a business attraction model that estimates potential new development based on accessibility improvements that would not be captured through traditional modeling. This category of benefit is very important for local and statewide analyses.

Organizational requirements – HEAT provides MDT staff with internal capability to perform their own simulations to estimate the economic effects of transportation improvements. HEAT (and other models including MCIBAS) still require specialized expertise by users who must possess an adequate knowledge of the statewide economy and industries to properly interpret the generated results. Montana has an economist dedicated to supporting the use of HEAT to assess transportation projects and plans. By comparison, MCIBAS is too complex to be used in-house by INDOT staff. Projects that have applied MCIBAS to assess benefits have required the use of consultants.

Role of Monetization in Organizational Decision-Making

Decisions concerning transportation investments are made by the Montana Department of Transportation's executive director, its administrator of planning, its Transportation Commission and the agency's district offices. The monetized benefits (resulting from travel efficiency improvements and economic benefits) generated by HEAT are passed on to members of these groups from an MDT economist working out of the central office. While a very high percentage (90 percent) of travel efficiency and economic benefits are believed to be monetized by HEAT, the model does not include estimates of the environmental, safety, and social benefits that may result from transportation improvements. In particular, the monetized data, today, are used for communications purposes and for internal analysis.

The models are intended for initial project/corridor analysis or program-wide analysis. Given the statewide capabilities, they are not intended to completely replace more detailed corridor/project studies that more closely evaluate local economic, transportation, environmental, and social considerations.

Conclusions

HEAT represents a leading edge analytical system to monetize industry/business effects within a benefit/cost framework for evaluating transportation projects. HEAT's comprehensive analytical modules are incorporated within a single GIS platform and allow agency staff more flexibility to run the model. The major challenge confronting the success of this approach is not analytical or mechanical, but rather institutional. Within agencies, decisions need to be made concerning where to apply HEAT-type economic development impact evaluations (corridor, long-range plan, project-level, etc.) as well as determining what resources can be dedicated to support the models (e.g., staff capabilities, and maintaining the essential knowledge necessary to apply/interpret these models and performance measures). Across transportation agencies, there are varied approaches in terms of modeling, tools, use of consultants (as opposed to in-house staff), selection of performance measures, and the instances in which economic impact metrics are used as part of an evaluation.

5.6 Case Study: Wisconsin Focus on Energy

Introduction

Organization - "Focus on Energy" (FOCUS) is Wisconsin's statewide energy efficiency and renewable energy initiative. It is a public-private partnership offering energy efficiency information and services to residential (with a special program for low income residents) and business customers throughout the state. The statewide program was created by the legislature in 1999 to meet the following six formal policy objectives through reducing the need for fossil fuels:

- improve energy efficiency and decrease usage,
- improve the health of the state's economy,
- reduce negative environmental impacts of energy consumption,
- facilitate market transformation by reducing market barriers to increased energy efficiency,
- increase system reliability (including electricity generation, transmission, and distribution in the state, and
- stimulate the energy efficiency services industry.

Through the program, the state pays local energy providers to install energy efficient equipment (e.g., light bulbs, refrigerators, showerheads, industrial motors, etc.) in homes and provide services to businesses and homes. The program is overseen by the Wisconsin Department of Administration (DOA), Division of Energy.

Case Study Selection – The FOCUS case study provides an example of techniques used by a non-transportation agency to monetize a number of social, environmental and economic impacts for use in performance evaluations. It was selected as a case study because the techniques used to monetize these impacts can be adopted for use in evaluating transportation investments and programs.

History of Monetization

The State of Wisconsin has been a leader in trying to monetize the impacts of programs and investments to better evaluate their true benefits and costs. In 1989, the Wisconsin Department of Transportation completed a ground-breaking study of the economic development impacts of a proposed new highway across the state. This study employed an econometric forecasting and simulation model to predict the impacts of alternative highway investments on job growth, personal income, and gross regional product. In 1994-95, the Department of Administration, Division of Energy conducted a study to measure the impacts of its energy efficiency programs on the state economy.

In 1999, the Wisconsin legislature created the Wisconsin Public Benefits program (which subsequently became FOCUS), to promote and support energy conservation, renewable energy development, and low-income services. FOCUS became operational in 2001 after a pilot program evaluation in the Green Bay area predicted net benefits would derive from Focus programs over time. As mandated by the legislature, the program is evaluated on an annual basis to ensure that users and the state are deriving benefits from the program and that it is cost-effective. This annual performance review, which uses historical data to measure the success of the program to date and to forecast expected future impacts, is used both to justify continued project funding and to make changes to the programs to better meet program goals.

Between 2003 and 2005, the Wisconsin of Department of Administration, Division of Energy undertook a comprehensive program evaluation to measure the realized and future benefits of the program in four categories:

- energy usage impacts,
- environmental impacts,
- low income participant benefits (with a focus on non-energy benefits), and
- economic development impacts.

The researchers employed both commonly used and innovative techniques to develop monetary values to measure the impacts in each category, and then used the impact measures in benefit/cost analyses of the program. These techniques and measures are described below.

Techniques for Monetizing Impact Measures

Energy-- The FOCUS evaluations include monetized values for both the direct energy savings and market effect energy savings. The direct energy savings are the "energy savings due to the energy-efficiency measures directly attributable to the programs and tracked by them. The direct energy savings are valued in terms of avoided cost to the customer of the avoided energy use over the expected life of the measure."[76] The monetary value of the savings is arrived at by calculating the energy savings that accrue to residential, business and industrial program participants (measured in terms of kilowatt hours and therms), and multiplying this savings by the unit cost of each type of energy (i.e., cents per kilowatt hour and cents/therm). The unit costs used in this evaluation represent the average unit costs from Wisconsin utility bills over a one year period. These values are shown in Table 5-5.

Table 5-5: Summary of Energy Saving Unit Costs for Wisconsin Focus on Energy

Avoided Costs	Cents/kWh*	Cents/Therm*
Residential	8.08	67.12
Commercial	6.45	54.87
Industrial	4.34	49.35

*Average WI utility bill, Sept. 2001-August 2002
Source: Focus on Energy Statewide Evaluation, Initial Benefit-Cost Analysis, Final Report, 2003.

The market effects energy savings are defined as the energy savings due to additional measures implemented outside the program by either participants or non-participants that would not have occurred without the program.[77] These are also valued in terms of the avoided costs to the customer. Both the direct and market effect energy savings represent efficiency benefits of the program.

Environmental Impacts

One important benefit of the FOCUS program is the reduction in emissions, also called avoided externalities, resulting from the implementation of energy efficient measures in residences, commercial establishments, and industrial facilities. Energy industry researchers (as well as transportation industry analysts), have long struggled with how to monetize the value of reduced emissions. However, recent growth in the emissions credits trading markets has provided standards for valuing reductions in emissions of sulfur oxide (SOx) and nitrous oxide (NOx). For this study, the researchers first estimated the total reductions in emissions (in pounds) of SOx and NOx resulting from program implementation. They then multiplied these totals by the market value of emissions trading credits ($/lb) to arrive at a monetized value of reductions in emissions for these two pollutants. Table 5-6 shows the values used for these calculations. This simple methodology, using accepted values for these two pollutants, can be easily used to monetize the value of reduced emissions related to a transportation investment.

Table 5-6: Summary of Externality Unit Costs for Wisconsin Focus on Energy

Avoided Costs	Cents/kWh	Cents/Therm
SOx*	0.09	
NOx*	0.08	
CO_2**	2.14	10.44

**Unit costs equal the market value for emissions trading credits*
*** Unit costs used by WI Public Service Commisison*
Source: Focus on Energy Statewide Evaluation, Initial Benefit-Cost Analysis, Final Report, 2003

Currently, there is not an active emissions trading market for carbon dioxide (CO_2) in the United States. To monetize the value of reduced CO_2 emissions, the researchers used a value of cents/kWh and cents/therm of CO_2 emission developed by the Wisconsin Public Service Commission (WPSC) in the 1990s.[78] The value developed by the WPSC was derived from values used by eleven other states at the time (see Table 5-6 above). There continues to be debate about how to most accurately measure the cost of CO_2 emissions, given that there is not currently an emissions trading market for this pollutant. The values used in this study do, however, provide one alternative that has been accepted by the State of Wisconsin.

Non-energy Participant Benefits - The Wisconsin Department of Administration (DOA) recognized that energy savings and emission reductions do not capture all the benefits derived from the FOCUS program. FOCUS also provides a range of non-energy benefits (NEBs) such as improved comfort, improved ability to pay energy and other bills, and the increases in property values typically associated with the installation of energy efficient appliances and materials. These types of benefits are difficult to monetize and their value may differ among program participants. However, because these benefits are an important outcome of the program, DOA felt it was important to assign a monetary value to the NEBs in order to calculate a more accurate monetary estimate of program benefits.

There are not standard monetary measures for NEBs. Therefore, consultants conducted a survey of 362 program participants, who were asked to compare the value of the NEBs to the energy savings they realized from the program. The survey was designed to allow three valuation methods (see Table 5-7) to derive monetary values for 21 NEBS, thus building in a mechanism to "check" the values assigned to the NEBs. (The 21 NEBs for which monetary values were derived include: home's overall comfort, ability to pay energy/other bills/ quantity or quality of lighting, noise from appliances of noise inside home, amount of noise from outside home, reliability of new equipment, appearance of home or property value, ability to control energy bill or understanding of energy use, likelihood of moving because of energy costs, equipment performance or features, number of calls to utility related to bills, number of bill payment or shutoff notices received, impacts on environment, number of sick days lost from work/school, water bill costs, frequency or intensity of chronic conditions such as asthma, frequency or intensity of other illnesses, headaches suffered by household members, doctor or hospital visits and related costs, medication costs, and safety of home.)

Table 5-7: Methods for Valuing Non-Energy Benefits

Comparative Analysis Techniques	Other Techniques
Verbal Scaling	Willingness to Pay
Reported Percentages	

The verbal scaling technique involved asking participants if they experienced a change in each of the 21 NEBs as a result of the FOCUS program. Then participants were asked if the change was negative or positive. If the answer was positive, they were asked if the change was somewhat more valuable, much more valuable, somewhat less valuable, or much less valuable compared to the energy savings. If participants identified the NEB as a negative impact, they were asked to identify if the change was somewhat more costly, much more costly, etc. than the potential energy savings. Using the results of these interviews, and based on the experience of the research team in valuing NEBs, each category of value or cost was assigned a coefficient or multiplier, which were then applied to the average savings associated with the program to develop a dollar value for each NEB. NEB rated as much more valuable than the energy savings received a multiplier greater than one, while a NEB rated as much less valuable than the energy savings received a multiplier of less than one. The multipliers for each NEB are then applied to the average energy savings, and the results added together to arrive at an estimated overall monetary value for NEBs associated with the program.

Because some respondents find it difficult to respond to a series of questions about each individual NEB, a second series of questions was included in the survey instrument to arrive at a monetary value for all NEBs combined. Respondents were ask, "think about the combination of all the positive effects you received from the

…program beyond energy savings. Would you say the combination of these effects is overall positive, negative, or no effect?" Then the respondent was asked a series of questions to compare the value of the benefits to the overall energy savings. Finally, they were asked what percentage more or less valuable the benefits were relative to the overall energy savings. The response of all respondents was averaged and applied to a monetary value for the energy savings to arrive at an overall value per program participant for the NEBs derived from the program. This technique is called "reported percentages."

One final set of questions in the survey attempted to directly identify program participants' willingness to pay for the NEBs. The questions asked how much participants would pay to get the NEBs back if they were taken away, as well as how much compensation they would accept in exchange for having the benefits taken away.

In the FOCUS program evaluations, the researchers relied on the results from the verbal scaling and relative percentages techniques, finding that the values obtained from the willingness to pay analysis were much higher and more volatile than those derived from the two comparative analysis techniques. The results of the two comparative analysis techniques allowed the researchers to arrive at an acceptable range for the monetary value of the NEBs associated with the program.

Economic Development

Because one of the goals of the FOCUS program is to improve the economy of the state of Wisconsin, the program evaluation included the use of a REMI economic forecasting model to document the impacts of the FOCUS program on the state's economy. The economic model captures how the program affects economic competitiveness, diversification, and shifts in economic activity between Wisconsin and other states. The purpose of the economic modeling was to track how the FOCUS program affects the flow of dollars through the economy, and produce a monetized value of these economic impacts to use in a benefit/cost analysis. Similar models have been used by transportation agency to project the economic impacts of a range of transportation investments.

The first step in analyzing the economic development impacts of FOCUS was to calculate the net direct impacts of the program, which comprised the inputs to the economic model. In this case, the inputs included program operations spending (i.e., the cost of operating the program and paying incentives to participants), household and business savings (in terms of the value of reduced energy usage), household and business costs (such as the cost of purchasing the energy efficient equipment), and other spending shifts (related to shifting patterns of spending and business sales among sectors of the state economy).

The economic model calculated how these direct economic impacts filter through the state economy, resulting in lower business operating costs, lower household living costs, import-substitution (e.g., money that was "leaking" from the Wisconsin economy to pay for coal and gas produced elsewhere is shifted to Wisconsin businesses that provide energy efficient equipment), increased orders to firms providing goods and services to Wisconsin equipment manufacturers and service providers, and re-spending of additional worker income in the Wisconsin economy. The model then produced measures of the impacts of the direct effects and the resulting shifts within the economy (on a year by year basis) in terms of changes in:

- total volume of business sales,
- total number of jobs by industry and occupation,
- total disposable income, and
- total gross regional product.

Business sales, disposable income, and gross regional product are all measured in monetary terms.

Economic modeling, whether to measure the impacts of an energy program or a transportation investment, must be carried out by trained economists. In this case, the Wisconsin Department of Administration hired economic consultants to calculate the direct effects of the program and accurately input these effects into the model. The consultants also analyzed the results of the model to clearly interpret the economic development impacts of the FOCUS program.

Benefit-Cost Analysis

The FOCUS evaluations included two approaches for comparing the benefits and costs of the programs. The "simple" benefit/cost test ("B/C test") is used to measure the value of all avoided costs as well as other benefits compared to program and participant costs, and is a modification of the commonly used "societal" B/C tests.

The simple B/C test used here differs from a traditional societal test in that, in addition to measuring avoided costs, externalities, and program and participant costs, it also includes non-energy benefits that accrue to individual program participants. The simple test is used here because the policy driver for FOCUS low income programs is equity for program participants. Therefore, the analysis counts as benefits both the benefits to program participants and societal benefits due to mitigated externalities and reduced ratepayer costs.

The FOCUS evaluation also includes an "economic development" B/C test which "…counts the same benefits and end-user costs, but instead of simply summing them, models their net effect on the Wisconsin economy."[79]

The purpose of the simple B/C test is to "consider the total benefit provided relative to the total amount of public (or ratepayer) money spent."[80] The benefits included in this test include the value of direct energy savings, the value to participants of direct bill payment, non-energy benefits resulting in dollar flows, internalized externalities

(NO_x and SO_x), the value of CO_2 emissions reductions, and the value of non-energy benefits that do not result in direct dollar flows, but which can be valued by participants (e.g., the value of increased comfort). The costs included are program operations and direct bill payments.

The economic development B/C test expands on the simple B/C test by considering benefits more broadly. The simple B/C test considers only one economic market – the market for energy efficient goods and services. The economic development B/C test considers the benefits to the economy as a whole. It does this by using the output from the economic forecasting model (value added (gross state product), personal income, and net corporate income) as well as non-energy benefits and non-economic externalities savings not included in the economic model. The costs included in the economic development B/C test are the same as those included in the simple B/C test.

For the FOCUS program, a 25-year analysis period was used for the benefit cost analysis. This period assumes that the program will be in place for 10 years, and that benefits will continue to accrue for an additional 15 years (the estimated life of the energy efficient equipment installed through the program). B/C tests were calculated separately for the Business Programs, Residential Programs, and Renewable Energy Programs, and then calculated for the FOCUS program as a whole. B/C tests were also performed for the Low Income Public Benefits Program.

Technical Guidance that Emerges from Case Study

The performance evaluation techniques used by the Wisconsin Department of Administration to assess the Focus on Energy program are significant in terms of the breath of the analysis measures, and the techniques and data sources used to monetize impacts that have traditionally been difficult to measure in monetary terms. In the FOCUS case study, the direct energy cost savings that accrue to program participants are the “user benefits” of the program. These are comparable to the efficiency or user benefits of a transportation project, measured in terms of travel time savings and operating cost savings. The methodologies for measuring use benefits for the FOCUS program are similar to those used for measuring transportation user benefits (i.e., total savings multiplied by the unit value.) The methods used to calculate the economic development benefits of the FOCUS program are identical to methods used to measure the economic development impacts of many transportation investments.

The use of emissions trading credits to measure the value of reductions in SOx and NOx emissions is directly transferable to the transportation sector. Further, in this study, researchers were able to place a monetary value on CO_2 emission reductions based on a range of values used in several different studies of utility program impacts. It is possible that transportation analysts can use monetary values for CO_2 emissions reduction used by the energy industry to begin to monetize the value of CO_2 emissions reductions resulting from transportation investments. This would represent a significant step forward.

The techniques used to place monetary values on the non-energy benefits of the FOCUS program can also be used in the evaluation of transportation investments. Many transportation projects result in quality of life benefits that are difficult to measure in monetary terms. These include impacts such as noise reduction, aesthetics, comfort, reduction in stress, etc. There are examples where willingness to pay tests have been used to derive values of difficult to monetize impacts of transportation investments, but the DOA study notes that respondents often overstate their willingness to pay, and individual responses vary widely from one another. The comparative analysis techniques of verbal scaling and reported percentages offer another approach to monetizing these impacts that appears to result in more consistent and reasonable results. The most difficult aspect of monetizing these benefits through comparative analysis techniques is deriving the coefficients to use for estimating the relative value of each benefit. In this case, the researchers relied on "in-house sources" derived from multiple studies performed by the research team. Identifying reliable coefficients to measure the benefits of a specific transportation investment may be difficult.

Conclusions

The Wisconsin Department of Administration, Division of Energy has adopted a comprehensive approach to evaluating the performance of the FOCUS programs, which includes the monetization of a wide range of program impacts. The monetization of impacts reflects the need of the DOA to produce the most accurate benefit/cost assessment possible to guide decisions about future program funding and inform decisions about improvements to the program.

The major strengths of the FOCUS program performance evaluations 1) the breadth of impacts that are monetized and incorporated into benefit/cost analyses, and 2) the transferability of these monetization approaches to the transportation industry. Because of the newness of the emissions trading market and the lack of agreement nationwide on the value of CO_2 emissions, there will continue to be some skepticism about the accuracy of impacts monetized with these values. The survey techniques used to derive monetary values for the non-energy benefits can be applied to the impacts of transportation projects, but may be of limited use if appropriate coefficients cannot be agreed upon. Nevertheless, they provide an important opportunity to begin to value previously non-monetized project impacts.

6. CONCLUSIONS

6.1 Overall Findings

This study reviewed existing forms of performance measurement techniques and the types of conversion factors and models being used. It then provided case studies showing how some organizations are increasing the degree to which they are converting performance metrics into dollar terms.

Overall, it shows that there is some widening of use occurring for monetization, particularly for environmental, safety and economic development impacts. While some dollar valuations have long existed for valuation of air pollution, deaths and economic development, there has been considerable controversy in the past about their magnitude. As time has gone on, it is interesting to see some convergence occurring in the range of generally acceptable values, particularly for the valuation of air pollution and human life.

At the same time, the valuation of travel time (and variability in travel time) for commercial vehicles has continued to increase as evidence becomes clear that previous methods have significantly undervalued those factors. Methods used for modeling and calculating the valuation of economic development impacts has also started to converge, as an increasing number of states are recognizing the need to include valuation of access and connectivity improvements.

Despite the forward movement in efforts to monetize performance measures, the use of monetized measures is still the exception rather than the rule. In addition, there are still many factors where little or no progress has yet been made at monetization measures. These include measures of land use, quality of life and social equity impacts of transportation programs. As long as that is the case, benefit/cost comparisons will still omit valuation of those factors, which will limit the use of this method for decision-making.

6.2 Issues Facing Users of Performance Measures

As part of this study, the research team held a "focus group" discussion with the panel of state transportation department representatives. The discussion identified key concerns for this constituency. The text that follows contains findings relative to these issues.

Use of Monetization for Decision-making. Focus group participants emphasized that agency priorities often vary from state-to-state, but that all agencies have a common need for assistance in decision-making. It was also noted that internal communities (i.e., internal agency staff) and external communities (i.e., legislators and public) often require different treatment.

Finding -- This issue highlights the need for more careful attention to the way that monetized performance measures are used in various communications formats. The case studies in this report do illustrate some examples of these varying formats. For instance, the ARC is oriented towards external audiences, and they routinely publish their performance findings in reports that are put on the Internet and distributed to federal officials and legislators. The Wisconsin case is also oriented towards external audiences (public and state legislators), though many of their reports are highly technical. On the other hand, the Montana monetized performance measures are used to a substantial degree by agency staff to aid in their own prioritization of resources.

Staff Resources Required. Focus group participants were concerned about the level of expenses and staff resources required to meet the data assembly and modeling requirements of different monetization techniques.

Finding -- The review of methods and more detailed case studies in this report both indicate that significant modeling is necessary for most of these performance measures. In many cases, the first step that requires significant resources is the modeling of non-monetary factors, using models that forecast changes in air quality, crash rates and economic consequences of transportation programs. Then, the application of tools to calculate economic impacts calls for additional models and expertise. In several of the case studies, separate technical staff had to be hired to assemble data and maintain the analysis models.

Extent of Regional Factors. Focus group participants were interested in the extent to which various types of data, methods, and factors are regionally dependent, i.e., must be modified for use outside the region for which they were developed.

Finding -- The review of methods showed that regional factors are important considerations insofar as states and regions vary in their different socio-economic characteristics, economic profiles and traffic conditions. For instance, under some circumstances it could be appropriate for the monetary valuation of safety improvements to be adjusted by differences in average age, wage rates and vehicle occupancy. That would particularly apply insofar as the valuation is based on actual costs of medical care and foregone wages. The monetary valuation of air quality improvements would not vary by local factors if they are based on emission trading prices (the approach gaining in popularity), though they could vary by area if valued on the basis of actual damage calculations. Finally, economic development impacts most certainly always vary by area, since there are wide differences in the nature of local economies, the extent of local congestion or other access constraints, and the extent to which local business activity is dependent on that traffic access.

Institutional settings. Focus group participants were interested in how staff of transportation agencies can best translate findings from non-transportation cases into useful lessons, while understanding institutional differences (such as differences in objectives and centralization) that can sometimes constrain transfer of methods from other settings.

Finding -- The case studies for non-transportation agencies were useful in two ways. The first was the focus on the *technical analysis methods;* and the second was the focus on *agency objectives*.

Clearly, energy and economic development agencies have very different objectives than transportation agencies, and this was reflected in the different performance metrics found in the case studies. Yet it was interesting to see from the case studies that the same types of economic models being used by state transportation agencies were also being used by the economic development and energy agencies. That indicated some clear convergence in approaches for monetizing performance measures. It was also clear from the review of methods and the case studies that some energy and environmental agencies are taking leadership roles in adopting emissions trading prices as a way of monetizing air pollution reduction impacts (in place of the more controversial approach of estimating damage changes). The Wisconsin case also showed how some energy agencies are monetizing low income household impacts. Finally, the ARC case showed how broader poverty reduction and economic development indicators can be applied for transportation investment.

Backward vs Forward-Looking Performance Measures. Focus group participants noted that performance metrics can be used in two distinct ways, (1) forward-looking to estimate the expected economic value of proposed programs, and (2) backward-looking to document the actual economic value of benefits realized from recent projects.

Finding -- The study findings reinforced the fact that forward- and backward-looking performance metrics often have different goals and audiences. Forward-looking performance measures are used in decision making and are used largely for internal audiences. On the other hand, backward-looking performance measures are used for validation and justification, and more often are prepared for external audiences such as legislatures. However, the two are interconnected for it is the existence of backward-looking impact studies on completed projects that provide a foundation of support for methods used in forward-looking benefit-estimations of newly proposed projects.

The case of the ARC and Wisconsin Focus on Energy were both examples of non-transportation agencies that have been issuing public reports to legislators with backward-looking performance measures to validate the usefulness of their programs.

Some of the transportation agencies were also providing annual performance measure reports to external audiences, though they were generally emphasizing non-monetary measurement of impacts in those reports.

Budgets. Focus group participants emphasized concern with budget and resource issues, including not only expense but also the level and types of staff resources needed to further monetize their performance measures. Ultimately, this consideration can affect determination of whether or not the benefit of these monetized measures for decision-making actually justifies the additional costs.

Finding -- In general, the case studies do indicate that there is some significant expense involved in obtaining additional tools and data sources to monetize various performance indicators. However, the range of expenses varies widely, and it is often not possible to distinguish costs of adding monetary forms of performance measures from costs of broader, pre-existing performance measurement and reporting systems. In most cases, the agencies have also had to engage economic specialists to maintain these tools and generate reports from them. Several agencies covered in the case studies have turned to consultants for this work (e.g., ARC), though others have had consultants set up the systems and then hired additional staff to maintain them (e.g., Montana).

Relative Usefulness of Monetization. Focus group participants expressed mixed opinions or uncertainty over the relative usefulness of monetizing performance measures, given that currently accepted methods can monetize some, but not all types of elements of impact.

Finding – The review of available techniques showed that some types of impacts have better developed and more widely accepted methods than others. Some of the newer, more comprehensive approaches featured in the case studies show promise, though most of them are too new to determine their ultimate benefit relative to cost. However, there does appear to be a widespread perception that the newer monetization processes have helped to sharpen measurement and understanding of benefit incidence and distribution. It is perceived by participants in the organizations featured in the case studies that the effort has helped to tell a more complete story to internal audiences as well as a more convincing story to external audiences.

However, it is still clear that there are factors that cannot be monetized without creating more controversy. These include factors such as monetizing impacts on wetlands, or the value of reducing income and job access disparities between areas. For this reason, further research is needed to develop acceptable monetization methods for a broader set of impacts. Additional research can also lead to better methods for internal resource allocation, such as the relative benefits of DOT spending on transportation security versus highway system preservation or highway system capacity enhancement.

Finally, it is important to remember that monetization can become less controversial over time. A few decades ago, many people objected to monetizing environmental measures, yet today such monetization has become much more common. While monetization is still less common for other aspects of transportation impact, this trend suggests that continued efforts to improve such impact or performance metrics can pay off in the future.

6.3 Guidance

One of the major products of this study was to be the development of guidance on the monetization of performance measures that traditionally have not been measured in monetary terms. As was shown in this report, some performance measures are more conducive than others for such an approach. In particular, it seems likely that performance measures shown in Table 2-1 relating to mobility, safety, system preservation, environmental quality/health and economic development hold promise for monetary metrics, whereas those measures relating to customer satisfaction, environmental justice, quality of life, security and sustainability are much more difficult. These latter measures could have monetary values placed on them through contingent valuation techniques, but it is not clear what value such information would provide to the decision making process.

The overall guidance that results from this study is that the information tableau presented to decision makers on the alternatives being faced or for system performance monitoring should include as many performance measures as is desired, with this performance framework including metrics that are monetized as well as those that are not. As was seen in the monetization example of safety performance in the State of Washington and in Atlanta, there is substantial value in providing decision makers with some sense of the economic cost to society of transportation system performance. The dollar metric is a measure that most everyone can understand, and one that can be related to different levels of performance achievement. However, it is not likely that all measures of concern to decision makers can be reduced to a dollar dimension.

APPENDIX A – EXAMPLES OF PERFORMANCE MEASURES

This appendix shows the types of performance metrics that are being used by selected state and regional agencies. It is organized by type of impact. While all of the performance measures are quantified, relatively few of them are measured in monetary terms.

Accessibility:

Atlanta Regional Commission
- Average trip length for home-based work and other trips
- Percent of households accessible to transit (within ¼ mile), by income
- Level of congestion in PM peak period

Tennessee DOT
- Percentage of population within a 25-minute drive time of a regional service airport
- Number of bicycle lane-miles leading to or within tourist destinations
- Travel time to state, regional, and national markets or to employment centers
- Number of operating ports and terminals
- Commodity flows from, to, within, and through state by rail
- Employment within one-half mile of transit corridors

Mobility:

Atlanta Regional Commission
- Average trip time for home-based work and other trips
- Average trip travel time for commercial vehicles
- Average delay per vehicle in top ten bottlenecks on the road network
- Transit mode share for home-based work trips
- Percent increase in number of transit riders

Arizona DOT
- Percent of person-miles traveled (PMT) by level of service (LOS); and
- Average delay per trip.

Safety:

Maryland Department of Transportation
- Annual number and rate of personal injuries on all roads in Maryland
- Annual number and rate of traffic fatalities on all roads in Maryland and toll roads
- Number of bicycle fatalities and injuries on all Maryland roads
- Number of pedestrian fatalities and injuries on all Maryland roads

- Customer perceptions of safety on the state's transit system
- Bus incidents per million vehicle revenue miles
- Compliance with annual Federal Aviation Administration safety certification
- Port of Baltimore compliance with the Maritime Transportation Security Act

<u>Metropolitan Transportation Commission (Bay Area)</u>

- Number of injuries and fatalities at identified safety "hot spots"
- Pavement Condition Index (freeways and roads)
- Average age of transit fleet
- Progress in completing bridge seismic retrofit program

Operations Efficiency:

<u>Maryland Department of Transportation</u>

- Maintenance expenditures per lane-mile
- Motor vehicle administration cost per transaction
- Operating cost per passenger
- Operating cost per passenger mile
- Average branch office customer wait time versus customer rating
- Airline cost per enplaned passenger
- Airport revenue per enplaned passenger
- Port revenue versus operating expense

System Preservation:

<u>Virginia DOT</u>

- Interchange spacing/Mainline adequacy
- Inclusion of other modes – HOV lanes, bike/pedestrian accommodations, park and ride lots, bus lanes, rail facilities, us pull outs, etc.
- Bridge conditions – Bridge sufficiency rating

<u>Arizona DOT</u>

- Reconstruction need
- Pavement condition
- Vehicle miles of travel (VMT) by pavement condition
- Bridge condition
- Vehicle trips by bridge condition.

Customer Satisfaction:

<u>Minnesota DOT</u>

- Percent of customers satisfied with the reliability of DOT's communications

<u>Maryland State Highway Administration</u>

- Satisfaction rating from drivers responding to the customer service survey
- Customer satisfaction rating of "A" or "B" after completion of construction projects

Economic Development and Land Use:

Minnesota DOT

- Percent of local governmental units whose plans and ordinances support Interregional Corridor Management Plans or Partnership Studies by addressing access management (measured as "substantial" or "limited")
- Percent of airports for which airspace or land have been protected to meet safety, noise, and height clearance requirements as per Master Plans.
- Percent of Interregional Corridor and bottleneck removal projects that have been identified in the 10-Year Work Plan for which rights-of-way have been protected
- Percent of Transit Advantages projects that have been identified in the 10-year construction program for which rights-of-way have been protected

Puget Sound Regional Council

- Do investments support the region's growth strategy? (Yes or no).

Lane County (Eugene), Oregon

- Acres of zoned nodal development
- Percentage of dwelling units built in nodes
- Percentage of new "total" employment in nodes

North Central Texas Council of Governments

- Proportion of land in the region with low traffic patterns
- Rate of bike, pedestrian, and transit use
- Growth rate of VMT per household and employee
- Air quality, congestion, and financial constraints

Delaware Valley Regional Planning Commission

- Percent growth in population compared to percent growth in developed land

Metropolitan Washington Transportation Planning Board

- Percent of regional growth in employment and households that will occur within regional activity clusters

Capital District Transportation Committee (Albany, New York)

Land use - transportation compatibility index*

** Note: this index captures the level of traffic intrusion in residential areas, defined as daily traffic divided by average residential driveway spacing. Compatibility between arterial and local access function is defined as daily traffic divided by average commercial driveway spacing.*

Energy and Resource Conservation:

Lane County (Eugene), Oregon

- Average fuel efficiency (VMT/gal)

Capital District Transportation Committee, Albany, NY

- Equivalent gallons of fuel/day for transportation capital, maintenance, operations

Environmental Justice:

Proposed performance measures in Atlanta—Atlanta Regional Commission

- Concentrations of minority and low-income populations
- Use of transportation modes by race and income

- Population by race and income within accessible distance to transport facilities
- Car ownership by race and income
- Comparison of carbon monoxide exposure by race and income
- Relocation of homes/ businesses due to transport construction by race and income
- Comparison of location of bus depots by race and income levels of communities
- Comparison of reduction or elimination of green space by highway or transit construction in communities of different races or income levels
- Demographics of location of current or planned air pollution monitors
- Access to jobs by race and income
- Access to other quality of life destinations by race and income
- Number of destinations available by transit by race and income
- Commute times by race and income by mode of transportation
- Frequency of transit service by race and income
- Ratio of transit seat miles to total number of passengers by race and income
- Cost of travel compared by race and income
- Number of bike and pedestrian accidents by race and income
- Comparison of customer satisfaction by race and income
- Comparison of financial investments in transportation modes, by race and income
- Comparison of financial investment in transportation by race or income level of community being served

North Central Texas Council of Governments

- Jobs accessible within 30 minutes by road by race
- Jobs accessible within 60 minutes by transit by race
- Level of service/congestion levels by sub-region

Environmental Quality:

Minnesota DOT

- Outdoor levels of ozone, nitrogen dioxide, carbon monoxide and particulate matter as a percent of the National Ambient Air Quality Standards (NAAQS).
- Estimated carbon dioxide emissions from motor vehicles in Minnesota.
- Percent of Mn/DOT fuel consumption defined as cleaner fuels.
- Violation Percent of National Pollution Discharge Elimination System permits
- Ratio of acres replaced to acres of wetlands affected.
- Percent of replaced wetlands where wetland types are as planned.
- Number of acres replanted with native species.
- Number of undeveloped acres converted to another land use.
- Time to complete Environmental Impact Statement, Environmental Assessment,
- Environmental Assessment Worksheet per project

Delaware Valley Regional Planning Commission

- Environmental conditions were generally positive as reflected by recycling, water quality and water withdrawal indicators, yet increasing waste generation and energy consumption reflect direct environment impacts.

Broward County, FL

- Water quality attainment

Maryland State Highway Administration

- Percent compliance rating for erosion and sediment control on construction projects, protecting nearby streams, drinking water and the Chesapeake Bay.
- Percent of Priority Historic Bridges so that their preservation is not in jeopardy.
- Percent storm water management facilities rated as functionally adequate.
- Percent of NPDES permit conditions
- Number of acres of wetlands and linear feet of streams restored
- Percent of the wetland, stream and reforestation commitments accomplished

Capital District Transportation Committee, Albany, NY

- Impacts on sensitive areas [wetlands, parklands, historic areas, archaeological sites); noise exposure index1

England's Highway Agency (not including Northern Ireland, Scotland, and Wales; equivalent to a large state DOT)

- Achieve 95% across the following 5 sub-targets—
- Air quality: Implement measures to improve air quality of at least 2 out of 21 prioritized Air Quality Management Areas
- Biodiversity: Achieve at least 7% of the published Biodiversity Action Plan
- Landscapes: Introduce at least 12 planting schemes to enhance the landscape
- Noise: Treat at least 200 lane kms of concrete road surface with lower noise surfaces
- Water: Treat at least 4 pollution risk water outfall sites

Quality of Life:

Metropolitan Transportation Commission

- Does project implement MTC-ABAG Smart Growth policies and objectives?
- Does project enable community residents to use a range of modes to access daily activities within the community?
- Does project support a community's development and/or redevelopment activities?

Capital District Transportation Committee, Albany, NY

Community quality of life measure[2]

Sustainability:

Newman and Kenworthy (distilled from World Bank, 1994)[81]

Energy and air quality

- total energy use per capita
- energy cost per dollar output
- proportion of alternative fuels
- total pollutants per capita
- total greenhouse gases

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[1] Index is the product of dBa and number of households in areas in which dBa exceeds accepted thresholds.

[2] Measure is a combination of quantitative and qualitative factors that reflect community quality of life by subregion (central cities, inner suburbs, outer suburbs, small cities and villages, rural areas).

- days meeting air standards
- average fuel consumption
- vehicles failing emissions test

Land, green spaces, and biodiversity

- agricultural land at urban fringe
- green space per capita
- % urban redevelopment
- # of transit-oriented developments
- density of pop. and employment

Transportation

- VMT per capita
- non-auto mode split
- work commute time and distance
- transit speed relative to auto
- service miles of transit
- cost recovery for transit
- parking spaces per 1,000 workers
- miles of separate bikeways

Livability, human amenities, health

- crashes per 1,000 population
- miles of pedestrian-friendly streets
- proportion of city with urban design guidelines
- proportion of city allowing mixed use, higher density development

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