# History and Application of Least Cost Planning for Transportation from the Mid-1990s

Prepared for

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***AASHTO*** – American Association of State Highway and Transportation Officials

***AST*** – Appraisal Summary Table

***BCA*** – benefit-cost analysis

***BCR*** – benefit-cost ratio

***CBA*** – cost-benefit analysis

***CICF*** – Central Indiana Community Foundation

***CICP*** – Central Indiana Corporate Partnership

***CIRTA*** – Central Indiana Regional Transportation Authority

***CITTF*** – Central Indiana Transit Task Force

***CO*** – carbon monoxide

***$CO_2$*** – carbon dioxide

***CoSS*** – Corridors of Statewide Significance

***CTB*** – Commonwealth Transportation Board

***DaSTS*** – Delivering a Sustainable Transport System

***DECC*** – UK Department of Energy and Climate Change

***DfT*** – Department for Transport

***DOT*** – Department of Transportation

***DSM*** – demand-side management

***FHWA*** – Federal Highway Administration

***FTA*** – Federal Transit Administration

***GAO*** – Government Accountability Office

***GICC*** – Greater Indianapolis Chamber of Commerce

***HOT*** – high-occupancy/toll

***HOV*** – high-occupant vehicle

***IMPO*** – Indianapolis Metropolitan Planning Organization

***INDOT*** – Indiana Department of Transportation

***IndyGO*** – Indianapolis Bus Corporation

***IRP*** – integrated resource planning

***IRR*** – internal rate of return

***LCP*** – least cost planning

***LUTI*** – land use/transport interaction

***MCA*** – multi-criteria analysis

***MIN*** – multimodal investment network

***MPO*** – metropolitan planning organization

***NATA*** – New Approach to Appraisal

***$NO_X$*** – nitrogen oxide

***NPPC*** – Northwest Power Planning Council

***NPV*** – Net Present Value

***O&M*** – operations and maintenance

***ODOT*** – Oregon Department of Transportation

***OTP*** – Oregon Transportation Plan

***PDC*** – Planning District Commission

***PM*** – particulate matter

***PSRC*** – Puget Sound Regional Council

***RCW*** – *Revised Code of Washington*

***REDF*** – Roberts Enterprise Development Fund

***ROI*** – return on investment

***RTPO*** – Regional transportation planning organization

***SOV*** – single-occupant vehicle

***TAZ*** – traffic analysis zone

***TDM*** – transportation demand management

***TREDIS*** – Transportation Economic Development Impact System

***TUBA*** – transport users benefit appraisal

***UK*** – United Kingdom

***VDOT*** – Virginia Department of Transportation

***VfM*** – value for money

***VOC*** – volatile organic compounds

***WAC*** – Washington Administrative Code

***WSDOT*** – Washington State Department of Transportation

At its core, least cost planning (LCP) is about comparative analysis and cost effectiveness. The utility industry, which coined the term, has had tremendous success using its methods to identify the least expensive options for providing a finite amount of electricity to its customers. In the utility industry, LCP considers a wide variety of options—from the demand as well as the supply side, from peak period pricing to offering energy-efficient light bulbs to customers for free or at a discounted price. As a result of this success, many have urged that the LCP process be translated for use in the transportation industry. However, this translation has proved difficult, as tradeoffs in transportation are more complex. With electricity, all decisions come down to one common unit: kilowatt-hours. In transportation, individuals make trips each day from varied origins and destinations. Trip-related decisions are made seemingly on the fly—time of travel, route selected, mode choice, and stops in between the origin and destination. Crafting a process to assess a project or network of projects of *least cost*, considering all of these factors, is no small task.

Yet this is what the Oregon State Legislature has asked the Oregon Department of Transportation (ODOT) to explore. As part of House Bill 2001 in the spring of 2009, the Legislature asked that ODOT consider "direct and indirect costs of demand and supply options to meet transportation goals, policies or both, where the intent of the process is to identify the most cost-effective mix of options" (Oregon House Bill 2001). As a way to start up and build a foundation for the LCP project, ODOT decided to survey the field of LCP as it applies to transportation, and to report back on opportunities, constraints, and successes from other agencies across the United States and abroad.

This discussion paper reports on the extent of LCP literature and practice as it relates to transportation. Chapter 2 of this paper describes the background of LCP, including its roots in the utility industry and its main technical attributes and principles. Chapter 3 reports the findings from four case studies. Each case study involved interviews with multiple individuals at transportation agencies that have applied LCP. Key lessons that could be applied to Oregon were extrapolated, along with key findings related to the inception

of LCP, technical approach, relation to LCP key attributes and principles, and future work programs. Chapter 4 reports key findings that span the case studies. These are summarized below, and are reported in more detail in Chapter 4:

- LCP can help agencies and stakeholders make more transparent and informed decisions.
- LCP applications should be developed in response to each agency's unique mission, mandate, and goals.
- Stakeholders are critical to crafting a successful tool and process.
- LCP applications typically start from a benefit-cost framework.
- LCP has been applied at the project and the system level.
- Applications have evolved and improved over time.

The report includes a series of appendixes that provide relevant detail about the technical subject matter of LCP:

- **Appendix A**—provides a glossary of terms used throughout the report.
- **Appendix B**—is an annotated bibliography of published literature, both from the research field and from practice. This bibliography was the subject of a desktop literature review that informed the selection of case studies.
- **Appendix C**—describes how certain "intangible" or "soft costs" can be quantified and monetized using LCP methods.
- **Appendix D**—references the November 2008 recommendation from the Oregon Transportation Vision Committee to Governor Ted Kulongoski to further the concept of LCP.

# 2 Description of LCP Principles, Attributes, and Methods

This chapter describes the terminology of LCP, discusses its origins in the electric utility industry, and presents the methods and processes used in transportation since the 1990s to emulate—either explicitly or implicitly—some of its principles and attributes. Content is drawn primarily from desktop research, including a review of the economic and transportation planning literature and available guidance published by transportation agencies in the United States and abroad. Appendix A is a glossary of key terms used in this chapter and through the document. Appendix B is an annotated bibliography with research and agency-specific sources of more information on topics presented in this chapter.

## What is Least Cost Planning?

LCP is generally understood as a set of analytical methods for assessing planning and project development options, and a process for selecting them. It is a framework within which a wide variety of options can be evaluated consistently to support decision making.

Perhaps confusingly, a defining characteristic of LCP is implied only indirectly in its name: the ability to consider demand-side options "on an equal playing field" with supply alternatives. This holds true for both the transportation as well as the utility sector (see the following section). Examples of supply alternatives include capacity expansion or investment in productivity-enhancing technology; examples of demand-side planning include strategies aimed at reducing or changing demand such as pricing or marketing campaigns promoting conservation.

Among the other characteristics of LCP identified in the literature are the explicit consideration of policy goals, the estimation of a broad range of effects (including environmental and social impacts), and the participation of the public in the development and assessment of alternatives.

LCP is not only a method or a set of methods. It also describes the process by which the methods are applied to evaluate planning options, and how decisions are made on the basis of that evaluation (in other words, how options are selected). Also central to LCP is the idea of optimization, of helping

identify and select the "least cost" option. But what exactly is meant by "least cost" when multiple objectives and a variety of effects—including environmental costs—must be considered? As explained below, this question has been addressed differently over time by varying agencies. Many recognize, however, that "least cost" analysis is closely related to—and in fact evolved from—cost-effectiveness analysis and benefit-cost analysis.

## Origins of Least Cost Planning

The origins of LCP have been documented in a number of publications, including the "1995 LCP Feasibility Report" commissioned by the Oregon Department of Transportation (ODOT).[1]

As explained in that report, LCP originated as part of the energy debate of the 1970s and was motivated by volatility in oil prices, federal legislation promoting the "proper and efficient" use of energy through consideration of more competitive supply and demand-side options,[2] and the ideas and activism of conservation proponents.

LCP initially was developed to consider a "broader set of choices" for meeting energy requirements, while reducing total societal cost. The term "LCP" was coined in a 1979 paper by a the Mellon Institute[3] that proposed estimating the energy savings associated with end-use efficiency strategies, and comparing the costs of these strategies with conventional, supply-side options.

Thus, a basic LCP procedure involved identifying capacity options to meet expected requirements, identifying demand-side initiatives, and selecting the cost-minimizing combination of the two sets of options. But, it was found that actual applications of LCP were far more diverse and complex than suggested in this description. A variety of criteria were used in defining cost, and a large array of issues and considerations other than cost entered into the selection of alternatives. As explained by Hanson, et al. (1991):

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[1] Rufolo, Anthony M., Lois M. Bronfman, and James G. Strathman. 1995. *Least-Cost Transportation Planning in ODOT Feasibility Report*. Center for Urban Studies, School or Urban and Public Affairs, Portland State University. 1995.

[2] 1975 Energy Policy and Conservation Act; 1978 National Energy Conservation and Policy Act; and 1978 Public Utilities Regulatory and Policy Act.

[3] Sant, R.W. 1979. *Least Cost Energy Strategy: Minimizing Consumer Costs through Competition*. Mellon Institute, Energy Productivity Center. Quoted in Rufolo et al. (1995), page 5.

> "A central goal of least cost planning is to provide energy services at minimum cost using demand and supply options. Minimizing the cost of energy services (…) extends beyond achieving the lowest cost for power supply; meeting energy requirements efficiently requires attention to economic, environmental, and social effects. Thus, the intent of least cost planning is to consider all relevant factors explicitly, and to balance competing interests."[4]

Over time LCP procedures evolved to meet the specific needs of the planning agencies and utilities involved in their application. An important phase in that evolution was the convergence of LCP and demand-side management (DSM) into integrated resource planning (IRP) in the later part of the 1980s.

Electric utilities had been involved in DSM for some time, but were reluctant to adopt the term "least cost planning" used by planning or regulatory agencies, in part because it might have implied that they had not always made "optimal" business decisions. LCP also had a broader perspective than the utilities' DSM (in other words, a broader range of impacts were considered); and was generally focused on the long term, while DSM was concerned with both the long and the short term. As a result, what was considered "least cost" by the utilities was not necessarily regarded as such by the agencies.

In practice, however, the two concepts (LCP and DSM) were often confused and over time, "the specific methodologies for selecting least cost strategies converged into (…) 'integrated resource planning'."[5] This convergence of views among the public sector and the private sectors led to the development of industry-wide best practices, although considerable variations in methods and processes remained.

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[4] Hanson, Mark, Stephan Kidwell, Dennis Ray and Rodney Stevenson. 1991. "Electric Utility Least-Cost Planning: Making it Worth within a Multi-attribute Decision-Making Framework." *Journal of the American Planning Association*, 57. Quoted in Rufolo et al. (1995), page 3.

[5] Rufolo et al. (1995), page 7.

Overall, the main characteristics of LCP (or IRP, which are now synonymous terms in the utility industry) in the energy sector have been summarized as follows:[6]

- Explicit consideration of objectives.
- Explicit consideration and fair treatment of a wide variety of options, including demand, supply, transmission and distribution, and pricing alternatives.
- Consideration of environmental and other social costs of providing energy services.
- Public participation in the development of the resource plan.
- Analysis of uncertainties associated with different external factors and resource options.

LCP represented a significant departure from "standard" planning practices, which had typically involved developing projections for future electricity needs and determining the best way to ensure that sufficient generating capacity would be available. This "standard" approach was comparable in many ways to what transportation planners traditionally do; that is, to develop travel demand projections and consider capacity improvements that help achieve a desired level of service. Efforts to improve that approach—and apply LCP to transportation—are discussed below.

## Applying Least Cost Planning to Transportation

In the 1990s, transportation planners—faced with rising highway construction costs and mounting environmental concerns—turned to the utility industry for guidance on how to improve their decisionmaking processes. Of particular interest were the methods used by utilities and energy planning agencies to compare demand-side options on an equal footing with capacity expansion, while considering a broad range of effects.

They soon realized, however, that much of the experience of the utilities was unique to that industry and that none of the methods and processes used in energy could be easily applied to transportation. Thus, Rufolo et al. (1995) observed:

> "(…) while the body of literature on least cost planning is extensive, its usefulness is primarily

[6] Adapted from Rufolo et al. (1995), page 7.

> to suggest a conceptual framework for analysis, and to offer a body of experience for comparison, rather than to provide a 'cookbook' for analysis" (Page 11).

This is true for a number of reasons. Not only are the institutional frameworks within which planning decisions are made in the two industries very different, but:

- LCP in the utility industry focused primarily on the generation and consumption of electricity, not on the wellbeing of customers; and while energy conservation efforts may not substantially affect customer satisfaction, changes in travel conditions (trip length, mode, delay, and so forth) typically do.
- There is no kilowatt-hour equivalent in transportation, making the definition of "service requirements" and the assessment of planning alternatives against these requirements difficult.
- The analysis of transportation planning options must account for different benefits to different users. Some transportation modes, for example, may not be available to all users because of their location, age, or income. There is no equivalent constraint in the utilities industry.
- Least cost transportation plans must account for the preferences and behaviors of travelers at a particular location, at a particular time. Preferences and behaviors across users are more uniform in energy planning.
- Finally, transportation output cannot be inventoried or moved around the network, limiting opportunities for resource optimization.

**Terminology Relevant to LCP Cost Minimization**

*Cost-Effectiveness Analysis*

*Benefit-Cost Analysis*

*Goals Achievement*

*Multiple Accounts Evaluation*

*Multi-Criteria Analysis*

*Community Impact Evaluation*

*Social or Sustainable Return on Investment*

Other differences have been documented in the literature, but while most authors agree that these differences are important and make the application of LCP to transportation challenging, none conclude that this application is infeasible.

## There is No One Way to do Least Cost Planning

The terms "least cost planning," "least cost analysis," and "integrated resource planning" are not commonly used in the transportation industry outside of academic or advocacy papers. Many of these papers were published in the mid 1990s, when adoption of methods and processes from utilities' best practices were just being considered. Besides,

there are no agencies in the United States (and abroad)—other than the Washington State Department of Transportation (WSDOT) and the Puget Sound Regional Council (PSRC)—that refer to their approach specifically as "LCP."

On the other hand, many organizations have actually introduced principles of LCP in planning and decisionmaking processes. This introduction has taken many forms and names—from cost-minimization to cost-effectiveness analysis, to goals achievement, or benefit-cost analysis. The following eight methods are employed by various transportation agencies and address principles and attributes of LCP:

- **Cost Minimization**—is an analysis that compares the costs of alternative ways of producing the same or similar "outputs," with a view to selecting the least cost option. LCP in transportation is often understood as a form of *project cost minimization*, similar to the life-cycle cost analysis described in the Federal Highway Administration (FHWA)'s primer on economic analysis[7], where a project has been selected and an agency is seeking to determine the lowest life-cycle-cost means to complete it.
- **Cost-Effectiveness Analysis**—in contrast, compares the outcomes associated with using a given amount of resources in different situations. This has also been described, perhaps confusingly, as an effort to determine the "least costly way of achieving a given level of benefits" or service. Cost-effectiveness analysis does not require that outcomes or benefits be expressed in monetary equivalent units. The term "cost effectiveness," itself, is often used to represent the unit cost of achieving a stated objective. Thus, in energy, projects may be compared in terms of cost per kilowatt-hour of electricity generated or saved. In transportation, the Federal Transit Administration (FTA) uses estimates of the "cost per new rider" in its assessment of applications for New Starts funding. One important limitation of cost-effectiveness analysis, however, is that it does not help define the "optimal" (socially or otherwise) level of service provision, because total benefits are not compared to total costs.

[7] Federal Highway Administration, Office of Asset Management , "Economic Analysis Primer", August 2003

- **Benefit-Cost Analysis**—or BCA, is a conceptual framework that quantifies both costs and benefits in monetary terms. It helps identify the alternative—or mix of alternatives—that maximize net benefits or "social welfare" per dollar invested. BCA has been applied to a variety of planning options and projects in transportation and other fields. Three of the case studies presented in Chapter 3 are based, fully or partially, on that framework. One attractive feature of BCA is its ability to account for both supply- and demand-side options. Congestion pricing and other efforts to reduce the demand for travel, for example, are easily captured though changes in "consumer surplus." Limitations of the approach for LCP, however, are numerous. First, there are often disagreements about the monetary valuation of impacts; in particular, those for which there are no market transactions (for example, air emissions). Second, some of the impacts that society—or a community—values may not be "monetizable." As illustrated in Appendix C, many of the effects traditionally considered "intangible" have been measured and monetized through research and can now be accounted for in an "extended" BCA, but this is not yet the case for all factors important to transportation decisions. Finally, the framework by itself does not easily allow for assessing how alternatives meet specific agency objectives or policy goals. All objectives are summed up in the overarching goal of maximizing social welfare. A metric—or group of metrics—is assigned to each objective; money or monetary equivalents are used as weights; and cost and benefit metrics (and indirectly "objectives") are aggregated by summation. In the end, options that perform relatively well on some impacts (for example, reduced congestion) may be ranked first through BCA even though they fail to meet important goals set by a community.
- **Goal Achievement**—is a category of methods focusing on the extent to which a plan or project is expected to meet objectives that have been set in advance. Variants of goal achievement used in regional and urban planning include:
  - *Bending On*—where an ideal urban form is defined and proposed planning options are assessed by their ability to approximate the form;

- *Goals Achievement Matrix*—which considers and summarizes multiple objectives combined with predefined weights;
- *Objective Fulfillment Analysis*—where alternative plans are ranked on multiple categories of objectives and where a summary score is defined for each plan. The score is then weighted by a probability of implementation, reflecting the difficulty of implementing the plan.

Forms of goal achievement have also been used in the utility industry and for transportation planning. Within the past decade, WSDOT proposed a method and tool (multimodal investment choice analysis) combining elements of goal achievement and BCA. Outputs from application of the method include monetized and nonmonetized impacts, standard BCA metrics (including net present value and benefit-cost ratio [BCR]), and the scoring of 17 outcome objectives (including preservation, improved security, and support for tourism).

- **Multiple Accounts Evaluation**—is an evaluation framework where the effects of a project or plan are divided into "accounts" to show different perspectives. Examples of accounts in transportation include: congestion management, safety, or affordable mobility accounts[8]. The framework accommodates both qualitative and quantitative evaluation criteria. The relative importance of each criterion, and account, may be determined by decision makers, as in multi-criteria analysis (MCA). Alternatively, the outcomes of a BCA, where only monetized effects are considered, may be summarized in a multiple accounts format to help assess the extent to which specific policy goals are addressed (where each goal is mapped into an account). Examples of multiple accounts evaluation in transportation planning include the Central Indiana Transportation Plan case study described in Chapter 3.
- **Multi-Criteria Analysis**—is a form of multiple accounts evaluation that considers many objectives and typically involves the attribution of a weight to each measurable objective (for example, see Table 2-1). In contrast to

[8] An "affordable mobility" account would summarize how a plan or project might impact the mobility of low-income households.

benefit-cost analysis that focuses on a unique criterion (typically, the maximization of social welfare), MCA allows users to deal with a set of different objectives that cannot be aggregated through monetary valuation. The method has been applied in various forms to the evaluation of transportation plans or projects. In the United Kingdom (UK), the New Approach to Appraisal (NATA) case study is generally considered to be a form of MCA, including a BCA component (or core) and a set of nonmonetized impacts categorized into objectives and subobjectives. Many of the applications of NATA, however, do not include weighting and the determination of an overall, summary score (nonmonetized impacts are simply reported in an appraisal summary table, for use in decision making). The U.S. Army Corps of Engineers' trade-off analysis procedures provide another example of multi-criteria decision framework applied to planning.[9]

**TABLE 2-1**
Differences between Multiple Accounts Evaluation and Multi-Criteria Analysis

| LCP Principle/ Attribute | Level Addressed with Multiple Accounts Evaluation | Level Addressed with Multi-Criteria Analysis |
|---|---|---|
| Use of quantitative and qualitative evidence | Low | High |
| Accounting for risk and uncertainty | Moderate | Low |
| Engagement of decision makers | Low | High |
| Serving as a Useful Basis for Choice | High | Moderate |

- **Community Impact Evaluation**—is a framework for the evaluation of planning options from the point of view of

[9] "Trade-Off Analysis Planning and Procedures Guidebook"; U.S. Army Corps of Engineers, Institute for Water Resources, April 2002

various groups within a community. Options are compared using costs and benefits expressed in monetary terms, quantified but not monetized (for example, number of households with improved air quality), and qualitative terms (for example, impacts on landscape). The approach was developed in the UK in the 1960s under the label "Planning Balance Sheet." It shares many of the attributes of BCA, but goes beyond monetized impacts, without proposing an approach through which nonmonetized effects can be weighed. Distributional impacts can also be presented within a BCA framework by estimating and reporting gains and losses to different groups, but are not accounted for in the standard summary metrics used in final evaluation and ranking.

- **Social Return on Investment** (ROI) and **Sustainable ROI**—are processes that explicitly account for a project's "triple-bottom line" by accounting for social, environmental, and economic impacts. Both processes build on BCA, supplemented by stakeholder participation and risk or uncertainty analysis. Sustainable ROI has many of the attributes of social ROI, but has a slightly different focus and has been used in different applications. While sustainable ROI has been applied predominantly to assess candidate infrastructure investments (in transportation and other industries), social ROI was initially developed by a San Francisco-based philanthropic fund (REDF, formerly the Roberts Enterprise Development Fund) for investing in social enterprises and retains a strong "third-sector" emphasis. Both can be interpreted as a form of BCA.

But how prevalent is the use of these methods and processes in the United States?

In 2005, the Government Accountability Office (GAO) conducted a study of options for improving information on the benefits and costs of highway and transit investments.[10] Of the transportation officials contacted through survey or interviews, the majority stated that their project selection process consider benefits and costs, but often do not involve a formal economic evaluation.

[10] Government Accountability Office, "Highway and Transit Investments: Options for Improving Information on Projects' Benefits and Costs and Increasing Accountability for Results," Report GAO-05-172, 2005.

The survey was conducted from August through October 2004 and was sent to all state departments of transportation (DOTs) and the 30 largest transit agencies in the United States. Questions in the survey pertained to the application of economic evaluation techniques to highway and transit capacity expansion projects that received federal funds. Of the 43 responding DOTs, three answered categorically that they do not analyze the benefits and costs of project alternatives. Among the remaining 40 agencies, 12 respondents indicated that they use Benefit-Cost Analysis "most of time"; and 11 said the same thing about Cost-Effectiveness Analysis. Yet, probing in the interviews conducted by the GAO revealed some of the claims of reliance on formal evaluation techniques to be overstated. This is consistent with other evidence suggesting that responding agencies may have interpreted the terms for "economic evaluation techniques" more loosely than economists would.[11]

The GAO survey also inquired about the importance of various factors in agency project selection decisions. Factors that can be assessed using economic evaluation techniques appear to play a significant role. In particular, a majority of responding DOTs said that they attach "great' or "very great" importance to "cost effectiveness." Unlike the question about the use of cost-effectiveness analysis, however, the question about cost effectiveness as a factor in decision making did not specify using a quantitative measure of cost effectiveness. Thus, responding agencies could answer that cost effectiveness plays an important role in their decisions even when they do not formally measure cost effectiveness.

Of the decision-making factors presented to respondents in the GAO survey, that which respondents rated as most important was "political support and public opinion." Out of the 43 responding state DOTs, 34 answered that this factor was of "great" or "very great" importance. The economic factors were also outranked by the availability of funding for a project, with 28 of the respondents also rating this of "great" or "very great" importance. In addition, interviews with state officials at locations the GAO visited indicated that "they often based their decision about whether to proceed primarily on

[11] Weisbrod, Glen and Martin Weiss, "Development of Benefit-Cost Policy in the Era of TEA-21," paper prepared for the Transportation Association of Canada, Benefit Cost Analysis Symposium. February 2001.

the project's perceived indirect benefits, such as desirable changes in land use or economic development."[12]

In addition to generally defined "LCP" methods and processes, a number of evaluation frameworks have been tailored by transportation agencies to meet their specific planning needs. WSDOT's Multimodal Investment Choice Analysis or the UK Department for Transport's NATA, mentioned above, are examples of these agency-specific approaches. Other applications identified in the course of this study include:

- The PSRC's BCA Framework developed for its long-term transportation plan, Transportation 2040.
- The Auckland Regional Transport Authority's *Integrated Transport Assessment*, a multi-criteria assessment process and tool designed to assess the impacts of alternative land use development and transportation plans.
- New Zealand Transport Agency's *Accessibility Planning*, a framework for the assessment of and planning for changes in accessibility.
- The Virginia Department of Transportation's *Multimodal Investment Network* (MIN) or *Corridors of Statewide Significance* (CoSS), a process by which planning options across modes are considered and evaluated.
- The European Union's application of strategic environmental assessment to corridors within the Trans-European Transport Network.

Additional information on these agency-specific approaches can be found in Chapter 3 (Case Studies) or in Appendix B, Annotated Bibliography.

A final consideration in this review of methods and processes is the extent to which transportation planning based on BCA constitutes LCP.[13] From the initial 1979 definition of LCP to the review of best practices in the electric utility and transportation industries, it is clear that, although BCA may help in the evaluation of planning options according to LCP principles, not all BCAs add up to LCP; in particular:

[12] GAO (2005), page 4

[13] In its 2009 guidance, the Washington State DOT presents LCP as a form of Benefit-Cost Analysis and refers to the FHWA primer on economic analysis for further information on the method.

- Not all monetized impacts may be considered in the analysis; and—as discussed earlier—nonmonetized impacts are either reported separately or neglected.
- The approach may not consider all planning options on an equal footing: BCA is often applied to assess capacity expansion for a specific mode, within a "silo," and fails to consider "softer," demand-side measures.
- The public may not be involved in the development and assessment of alternatives; many BCA are, in fact, conducted within a "black box," with limited disclosure of estimating assumptions and cause-and-effect relationships.
- Uncertainties in demand forecasts and estimating assumptions may not be accounted.

Besides, measurement of the extent to which different objectives are met and different social groups are impacted requires adjustments to the frameworks described above. Considerations of nonmonetized impacts may also require some form of multi-criteria or tradeoff analyses.

These issues are further discussed in Chapter 3, where four case study applications are described in detail and assessed against a set of LCP principles and technical attributes developed from the literature.

## Principles of Least Cost Planning

To be consistent with LCP, a transportation planning approach should conform to these principles:

1. The evaluation framework rolls up multiple goals.
2. The range of Oregon-specific transportation policy goals and objectives can be addressed.
3. A broad range of possible multimodal capacity, demand management, land use, maintenance, and other planning options can be considered.
4. Members of the community and decision makers are engaged in the planning and decisionmaking process.
5. The approach facilitates the adoption of a meaningful, relevant, and operationally useful basis for choice.
6. The methodology can be applied at the project-specific level, and the collective (multiproject) level.

7. The approach has been used for transportation planning.

## Technical Attributes of Least Cost Planning

In the same spirit, a LCP transportation planning approach should display these technical attributes:

1. Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units).
2. The approach makes use of quantitative and qualitative evidence.
3. Impacts on users (for example, commuters using a new transit system along a previously congested corridor) and nonusers (for example, members of the general public who do not travel within the corridor, but may benefit from improvements in air quality in the vicinity of that corridor) are estimated.
4. The approach accounts for indirect effects such as changes in local employment and land use.
5. Interactions ("synergies") among planning options are considered.
6. The approach explicitly accounts for risks and uncertainty in forecasts and cost and benefit calculations.

The extent to which the four case studies address the key technical attributes and principles of LCP is described in Chapter 3.

# 3 Case Studies

This chapter presents the findings from four case studies that explore how the principles and attributes of LCP are currently being applied by agencies across the United States and abroad. Special effort was made to study a diverse mix of case study applications. The case studies described are diverse both in scope (from national, to statewide, to regional applications) and in content (program- as well as project-specific applications). These studies were undertaken to better understand best practices for developing LCP applications for transportation, common pitfalls, and lessons learned. Special attention was paid to how LCP was used in transportation decision making.

The case studies represent some of the most advanced and well-documented examples of LCP in the transportation industry. Case studies were selected following a desktop literature review. This review, summarized in Appendix B: Annotated Bibliography, focused on agencies that employ key principles and attributes of LCP. The four case studies selected are summarized in Table 3-1.

**TABLE 3-1**
Selected Least Cost Planning Case Studies

| No. | Geography | Lead Agency | Scale of Effort | Project/Program |
|---|---|---|---|---|
| 1. | Washington State | Puget Sound Regional Council | Regional (led by public agency) | Transportation 2040 |
| 2. | United Kingdom | United Kingdom Department for Transport | National | New Approach to Appraisal *Refresh* |
| 3. | Virginia | Virginia Department of Transportation | Statewide | VTrans2035 |
| 4. | Indiana | Central Indiana Transit Task Force | Regional (led by private side) | Central Indiana Transportation Plan |

Interviews were conducted by phone or in person with two to four individuals for each case study. For some case studies (Virginia), all interviewees were with the same agency. For others (Washington), each interviewee represented a different agency. A series of questions, shown below, were customized to each case study and sent in advance of the interview.

**LCP Case Study Questionnaire**

Give us an overview of your agency and its planning responsibilities.

1. To what extent does your agency apply LCP principles? In what specific application? How does it work?
   a. What issues or impacts do you consider in your evaluation and decisionmaking process?
   b. How are nonquantifiable impacts treated in your decisionmaking process?
   c. How are you valuing externalities? How did you establish the assumptions used in the valuation of externalities (e.g., emission costs)?
   d. Does your approach allow for constrained optimization, where specific goals (in terms of air quality or emission targets, for example) must be met?
2. When was LCP introduced at your agency? What was the mandate or context?
3. What was the process that your agency went through when thinking about how to apply LCP? Who was involved in developing the process, and what were some of the key questions that were addressed?
   a. Who are the stakeholders engaged in planning and decision making? Are there any critics? Who are they and what are their main criticisms?
   b. How do you involve the community or general public?
4. How specifically do you use LCP with project selection and priority determination?
   a. Is the LCP approach you are using scalable?
   b. Are you using a different approach for rural vs. urban plans or projects?
5. Are the benefits of multimodal options considered? Are you accounting for synergies across modes? How?
   a. Are multiple freight modes considered?
6. Are you accounting for risk and uncertainty? How?
7. Are you considering possible changes in the build environment in your long-term transportation plans?
8. In your opinion, how effective has LCP been at your agency?
9. Do you plan to continue using LCP, and if so, do you have a work plan to improve certain elements of its use? If so, what elements are you focusing on for improvement?

Each case study covers four basic topics:

- How was LCP introduced (the mandate or inception)?
- How was the technical approach to LCP developed?
- How were the principles and technical attributes of LCP applied?
- What is the work plan for future improvements of the tool?

## Puget Sound Regional Council Transportation 2040

PSRC is the metropolitan planning organization (MPO) for Washington state's Puget Sound region. Six of Washington's ten largest cities are represented by PSRC, including Seattle, Bellevue, Tacoma, and Everett. PSRC has adopted the principles of LCP in Transportation 2040, central Puget Sound's 30-year transportation investment action plan, finalized in April 2010. Transportation 2040 is the transportation-specific component of VISION 2040, the region's comprehensive plan; and is an update of Destination 2030, PSRC's first and well-known application of LCP principles.

LCP helped the authors of Transportation 2040 shape a vision for transportation investments in the Puget Sound region by identifying the *net value* associated with each possible long-range regional transportation investment scenario. This net value, described in the following pages, quantifies and monetizes the soft and hard costs associated with various scenarios: highway capacity, transit investments, and road pricing, among others. This allowed Puget Sound decision makers to better understand and compare the tradeoffs associated with each scenario, and contributed to a more balanced and informed decisionmaking process.

Transportation 2040 communicates the region's priorities to federal and state policymakers, and provides a framework for future regional decisions. The prioritization of projects within this framework assists decision makers with implementation of key regional projects and programs. The plan is intended to be strategic and flexible in order to respond to evolving local, regional, state, and national policies and priorities.

## Inception

From the late 1980s to the early 1990s, the Northwest Power Planning Council (NPPC) developed an LCP program as a method for prioritizing new power infrastructure investments that are both environmentally sensitive and cost effective. The Washington state legislature envisioned that this program would be translated into transportation investments, and, in 1994, passed Senate House Bill 1928 (codified as Revised Code of Washington [RCW] 47.80.030), which required that all regional transportation planning organizations (RTPOs) develop regional transportation plans based on LCP methodology by the Year 2000. RTPOs in Washington are formed through the voluntary association of local governments within a county or contiguous counties. RTPO members include cities, counties, WSDOT, tribes, ports, transportation service providers, and private employers.

The specific language of RCW 47.80.030 is as follows:

> *Each regional transportation planning organization shall develop in cooperation with the department of transportation, providers of public transportation and high capacity transportation, ports, and local governments within the region, adopt, and periodically update a regional transportation plan that:*
>
> *Is based on a least cost planning methodology that identifies the most cost-effective facilities, services, and programs.*

The implemented Washington Administrative Code (WAC) 486-86-080, adopted in May 1997, required that all direct and indirect costs be included in least cost planning. It also left room for least cost planning methodology to evolve and be incorporated as it is developed.

The specific language of WAC 486-86-080 is as follows:

> *The methodology shall consider direct and indirect costs and benefits for all reasonable options to meet planning goals and objectives. The methodology shall treat demand and supply resources on a consistent and integrated basis. The regional transportation planning organizations shall consult the guidelines set forth by the department for implementing a*

**Washington Statewide Guidance**

Per WAC 486-86-080, WSDOT has developed LCP guidance for use by MPOs and RTPOs. RTPOs around the state are encouraged by WSDOT to use this simplified checklist to develop transportation plans:

1. What are this region's objectives for this transportation plan?
2. What are the performance measures that indicate the RTPO has optimized its plan?
   a. Region-wide
   b. In specific subareas, if appropriate
3. What alternatives were developed initially for this plan?
4. How were the plan's alternatives refined and evaluated?
5. How were the following factors addressed in creating and evaluating these alternatives?
   a. Life-cycle costs
   b. Multiple modes
   c. Demand projections
   d. Supply side limitations
   e. Externalities
6. How were startup capital costs weighed against results?
7. Did the planning process use benefit-cost analysis, and if so, what method(s) and what were the results?

Note: WSDOT's guidance was issued in 2009 and therefore was not used to develop Destination 2030 or Transportation 2040.

*least cost planning methodology. Regional transportation plans should incrementally incorporate least cost planning methodologies as these concepts are developed. The regional transportation plan adopted after July 1, 2000, shall be based on a least cost planning methodology appropriate to the region.*

PSRC first applied the principles of LCP in Destination 2030. Indeed, Destination 2030 served as the first application of LCP to a regional transportation plan within the state of Washington (WSDOT's Multimodal Investment Choice Analysis, launched in 1999, employs principles of LCP on a statewide basis). Destination 2030 explored the optimization of cost effectiveness for making major investment and policy decisions. For its update in Transportation 2040, the LCP nomenclature was no longer used, simply referring to the process as an extended BCA framework.

## Technical Approach

The technical approach to LCP employed in Transportation 2040 most closely resembles the extended BCA framework described in Chapter 2. The PSRC developed a methodology for program evaluation for application to transportation BCA. The BCA provides information that compares the value of benefits and costs that accumulate over time as a result of choosing one set of transportation improvements over another. The purpose of the analysis is to compare the benefits with the implementation costs associated with a set of transportation improvements. If the sum of the benefits exceeds the costs, the improvements could be viewed as a worthwhile expenditure. Different sets of improvements and qualitative data can then be compared to decide which set of transportation improvements offer the greatest value.

Figure 3-1 illustrates the main components of PSRC's BCA framework.

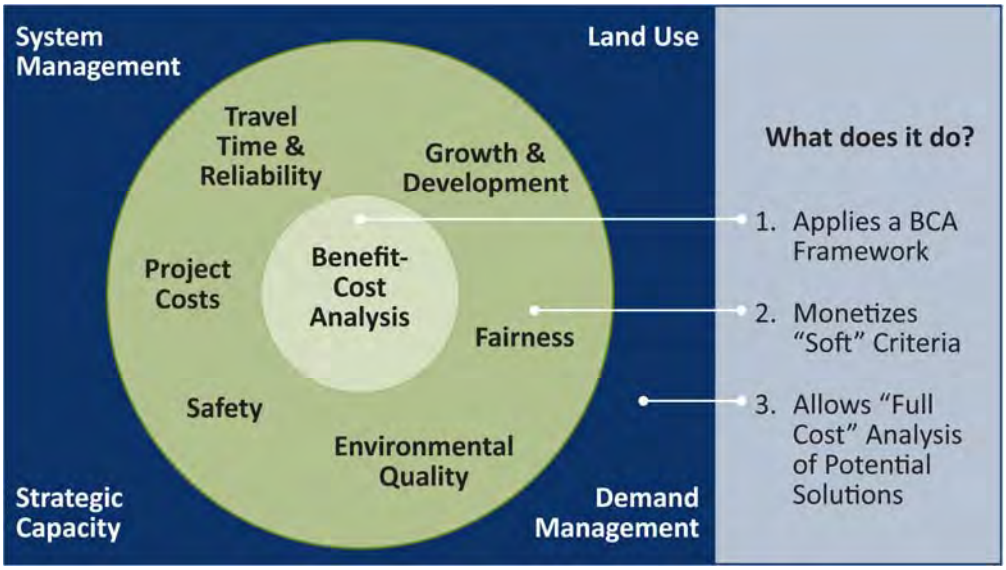


**Figure 3-1:** Benefit-Cost Analysis Framework
(Analysis and Forecasting at PSRC, October 2009, Pg. 3.)

A benefit-cost accounting software program was developed specifically for the PSRC on the basis of the American Association of State Highway and Transportation Officials (AASHTO) Red Book[14] parameters. PSRC uses its regional travel demand model software (EMME/3[15]) as the platform for BCA customization. Built into the travel demand model are various trip cost, time, vehicle class, and time of day information aggregated at either the origin-destination pair or links in the model network. There are 60 million individual origin-destination pairs, within 938 individual traffic analysis zones (TAZs), in the network. Each model run of this data is compared directly with the base case scenario in order to determine consumer surplus and environmental benefit. The base case for the PSRC model includes existing transportation infrastructure and future infrastructure improvements for which funding is committed or considered reasonable within current funding scenarios. A Web-based user interface compiles results with programmable input parameters and organizes data in output files that can be opened with standard spreadsheet software.

[14] American Association of State Highway and Transportation Officials, 2003. *A Manual of User Benefit Analysis for Highways.* Intended to help state and local transportation planning and policy officials and other transportation professionals evaluate user benefits of highway improvements. Generally considered the primary BCA guidance for transportation projects.

[15] EMME/3 is a travel demand forecasting system for urban, regional, and national transportation planning. Produced by INRO, it is the successor to EMME/2, an internationally recognized leader in travel demand modeling software.

The methodology articulated in Transportation 2040 centers around a BCA framework that quantifies (among others): travel time, accident costs, vehicle owner/operating costs, travel time un-reliability, facility operating costs, facility capital costs, and vehicle emissions costs. The steps in PSRC's BCA process include:

1. Define project alternatives and base case.
2. Determine level of detail (spatial, temporal, user segmentation).
3. Develop basic user cost factors.
4. Select economic factors.
5. Obtain traffic performance data for explicitly modeled periods.
6. Measure user costs for affected link(s) or corridor(s).
7. Calculate user benefits.
8. Extrapolate/interpolate benefits to all project years.
9. Determine present value of benefits and costs.

*The base case for the PSRC model includes existing transportation infrastructure and future infrastructure improvements for which funding is committed or considered reasonable within current funding scenarios.*

Steps 1, 2, and 5 are handled directly in the PSRC travel demand model. Steps 3 and 4 are user-defined parameters in the BCA tool. Examples of basic user cost factors include: values of time, vehicle unit operating costs, accident rate and cost parameters, and vehicle emission rate and cost parameters. Examples of economic factors include discount rate, analysis period, evaluation date, and inflation rates. Steps 6 and 7 involve internal processes of the BCA tool program. Steps 8 and 9 are implemented in a standard spreadsheet software package.

This process results in a number that represents the present value of all benefits minus all costs for a set of transportation improvements. This number is not—nor is it meant to be—a solution. The number associated with each set of improvements, along with qualitative impacts and transparent documentation of the analysis, is presented to decision makers. Decision makers then assess both the present value and findings from the qualitative assessment to determine which scenario represents the greatest value to the region.

| APPLICATION OF LCP PRINCIPLES | | |
|---|---|---|
| NO. | LCP Principle | Found in PSRC Case Study? |
| 1 | Multiple goals | ✓ |
| 2 | Oregon-specific policy goals | Partially |
| 3 | Demand management and other planning options | ✓ |
| 4 | Engagement of communities and decision makers | ✓ |
| 5 | Useful basis for choice | ✓ |
| 6 | Project-specific or multiproject | Multiproject |
| 7 | Has been used in decision support | ✓ |

Seven LCP principles (listed in Chapter 2 of this paper) were used as a basis for analyzing each case study. A description of how PSRC's BCA tool addresses each principle category follows.

### *Principle #1:*
### The evaluation framework rolls up multiple goals

The goals of Transportation 2040 include:

- Improve the mobility of people and goods.
- Create an efficient land use pattern for the provision of infrastructure, facilities, and services.
- Promote economic prosperity.
- Protect the natural environment.
- Promote an overall high quality of life.
- Distribute transportation benefits and costs equitably.

The BCA tool monetizes as many of the goals listed above as possible in order to sum them as value. Parameters are established so that scenarios meeting the goals are given a higher net value. The higher the net value of a scenario, the better it has performed. Summed values for each scenario are displayed side-by-side so that decision makers can weigh the benefits and constraints of each scenario in relation to established goals. Goals that cannot be monetized are presented qualitatively and are also used in the decisionmaking process.

### *Principle #2:*
### The range of Oregon-specific transportation policy goals and objectives can be addressed

PSRC's evaluation criteria fall within seven categories. Four of these criteria mesh well with the Oregon Transportation Plan (OTP) goals. It is important to note that the OTP goals are only one example of Oregon's transportation goals. These comparisons are shown in Table 3-2.

**TABLE 3-2**
Oregon Transportation Plan Goals Compared to PSRC Criteria Categories

| Oregon Transportation Plan Goal | PSRC Criteria Category |
|---|---|
| Mobility and Accessibility | Mobility |
| Management of the System | |
| Economic Vitality | Economic Prosperity |
| Sustainability | Environmental Stewardship |
| Safety and Security | |
| Funding the Transportation System | Finance |
| Coordination, Communication, and Cooperation | |

Although no application outside of Oregon will truly represent the Oregon-specific transportation policy goals and objectives, the Oregon Transportation Plan goals represented by Transportation 2040's evaluation criteria categories include mobility and accessibility, economic vitality, sustainability, and funding the transportation system. This demonstrates that many of Oregonians' most important values have been successfully translated into quantifiable, monetizable criteria for comparison across modes.

### *Principle #3:*
### A broad range of possible multimodal capacity, demand-management, land use, maintenance, and other planning options can be considered

Different combinations of actions such as tolling, road capacity, transit supply, and so forth, were run through the model to determine the combined effects on user costs and benefits. This process helped identify synergies across modes.

The land use model UrbanSim can interact with the travel demand model to predict land use changes in the built environment over time. UrbanSim and the travel demand model send data back and forth four times between the base year and the plan year 2040. More iterations would improve the accuracy of the data but not enough to justify the additional time and resources required to do so. Ultimately the data fed into the BCA is from the travel demand model. PSRC used UrbanSim as part of its analysis and forecasting for Transportation 2040, observing the land use effects of each regional scenario. The alternatives' impacts on undeveloped land were analyzed through UrbanSim. The alternatives that included transportation options promoting dispersed, low-density urban development (for example, commuter rail, and rural bus routes) were reported to result in *more* pressure to convert undeveloped rural land to urban use. The alternatives that included transportation options promoting high-density urban development in existing urban areas (for example, intercity bus routes, streetcar, and bicycle/pedestrian improvements) were reported to result in *less* pressure to develop rural land.

### *Principle #4:* Members of the community and decision makers are engaged in the planning and decisionmaking process

The PSRC Executive Board, which includes mayors, county executives, members of city councils, members of county commissions, and the WSDOT Secretary, approved a set of economic principles that serves as the basis for the BCA tool. This Board, which represents the decisionmaking body at PSRC, remained involved at key milestones throughout development of Transportation 2040, and ultimately selected the preferred transportation investment scenario.

However, this Board did not participate in the details of the BCA tool's technical development. The tool was developed predominantly by PSRC staff and outside technical experts working from peer-reviewed recognized research with input at key points from a committee of PSRC board members and agency staff.

According to PSRC, the public was not actively involved in the development of the BCA methodology or the development of coefficients for individual BCA elements. The public did weigh

in on the BCA methodology and some public comments have been incorporated into the agency's work plan for future tool improvements.

### *Principle #5:*
### The approach facilitates the adoption of a meaningful, relevant, and operationally useful basis for choice

In order for the PSRC's BCA to provide a meaningful basis for choice, the entire process needed to be made transparent to the decision maker. The assumptions made throughout the process were presented so that the decision maker could be confident in the validity of the BCA. Typically, the process used to determine the end result is as important as the result itself. Where qualitative data were combined with quantitative data, every effort was made to provide detailed information so that an informed decision could be made regarding the weighting of impacts that were measured differently.

Some important elements of LCP are not specifically incorporated in the present value determination. One such element is equity. Equity can be evaluated, and indeed has been explored by PSRC for discussions related to Transportation 2040. Equity was analyzed by identifying which TAZs were associated with low-income residents and/or high percentages of minority residents. Benefits and impacts were then isolated for those TAZs and compared to the region as a whole to identify whether impacts and benefits were equitable. PSRC did evaluate equity of benefits and performance region-wide and by subarea, including areas with high concentrations of low-income and minority households, and with different user types (single-occupant vehicle, or SOV, high-occupant vehicle, or HOV, transit, freight). The analysis showed higher net benefits for low-income and minority households than the region as a whole. On a per-trip basis, benefits to transit, carpools/vanpools, and freight operators were substantially higher than benefits to SOVs.

### *Principle #6:*
### The methodology can be applied at the project-specific level, and the collective (multiproject) level

Currently, the travel model is used in plan level scenarios in which multiple projects are analyzed simultaneously. For Transportation 2040, alternatives were analyzed against the

baseline alternative with each alternative containing multiple projects. The process was focused on deciding on a preferred alternative transportation plan and encompassed the most cost-efficient mix of transportation projects. In the future, more effort will be made to apply the model to specific projects.

### *Principle #7:* The approach has been used for transportation planning

The current BCA aids decision makers in their ability to make informed decisions regarding transportation planning for the future. It by no means dictates which alternative should be chosen, but it does provide guidance and a set of tools to make the most informed decision possible.

| APPLICATION OF LCP TECHNICAL ATTRIBUTES | | |
|---|---|---|
| **NO.** | **LCP Technical Attributes** | **Found in PSRC Case Study?** |
| 1 | Facilitates comparison of options | ✓ |
| 2 | Uses quantitative and qualitative evidence | Both |
| 3 | Considers impacts on nonusers | ✓ |
| 4 | Accounts for indirect effects | |
| 5 | Considers interactions and synergies | |
| 6 | Accounts for risk and uncertainty | ✓ |

Descriptions of the six technical attributes of LCP (also listed in Chapter 2 of this paper) in relation to the PSRC Transportation 2040 example follow.

### *Technical Attribute #1:* Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units)

Many, but not all, of the criteria measures in the PSRC case study are estimated in monetary values so they can be included in a benefit-cost result. Examples of criteria under the “mobility” criteria category that are monetized include: travel time savings, improved reliability benefits, and vehicle operating and ownership benefits. Examples of criteria under the “finance” criteria category that are monetized include: facility operating cost, capital cost, operating revenues, and

influence of finance on the economy. Under the "environmental stewardship" criteria category, vehicle and stationary emission benefits are monetized. Under the "quality of life" criteria category, accident cost savings are monetized. Finally, the criteria category "economic prosperity" is monetized, but not included in PSRC's BCA because the benefits are already reported in the other measures.

The advantages of the benefit-cost approach are that both benefits and costs can be combined to assess the potential economic consequences of a particular transportation alternative. The disadvantage is that nonmonetizable measures cannot be directly included. These qualitative measures are presented in conjunction with monetized results in an effort to provide the decision maker with all information available in order to make an informed, comprehensive decision.

### *Technical Attribute #2:*
### The approach makes use of quantitative and qualitative evidence

Quantitative data are analyzed and presented through PSRC's BCA. Qualitative data are organized so that they can be easily interpreted by decision makers and combined with quantitative data in a way that makes logical sense. The evaluation summary table shown in Figure 3-2 clearly shows which evaluation criteria are quantitative and which are qualitative. An example of a criteria category that includes both quantitative and qualitative information is 'Environmental Stewardship'. Vehicle and stationary emission benefits are monetized while impervious surfaces, agricultural and natural resource lands, and energy usage from vehicle and building use are qualitatively designated as positive or negative change. Both quantitative and qualitative information is provided to the decision maker so that they're able to make a completely informed decision.

| Evaluation Criteria | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 4 | Alt. 5 | Preferred (Constrained) | Full Preferred |
|---|---|---|---|---|---|---|---|
| **Mobility** | | | | | | | |
| *M1. Travel Time Savings* | $1,850 | $2,510 | $3,440 | $2,890 | $3,560 | $5,020 | $6,390 |
| *M2. Improved Reliability Benefits* | $290 | $410 | $1,000 | $1,140 | $1,290 | $1,070 | $1,180 |
| *M3. Vehicle Operating and Ownership Benefits* | -$93 | -$189 | -$125 | $200 | $13 | $73 | $213 |
| *M4. Other User Benefits* | $17 | $38. | $77 | -$15 | -$457 | $89 | $34 |
| **Finance** | | | | | | | |
| *F1. Facility Operating Cost* | -$360 | -$160 | -$300 | -$510 | -$1,030 | -$1,570 | -$2,600 |
| *F2. Capital Cost* | -$640 | -$2,310 | -$1,670 | -$1,650 | -$1,700 | -$1,560 | -$2,770 |
| *F3. Operating Revenues* | $180 | $257 | $2,940 | $3,660 | $7,100 | $3,500 | $5,360 |
| *F4. Influence of Finance on the Economy* | -$134 | -$363 | -$46 | $44 | $138 | $224 | $103 |
| **Growth Management** | | | | | | | |
| *GM1. Population* | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| *GM2. Employment* | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| *GM3. Jobs to Housing Balance* | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| *GM4. Population and Jobs in Centers* | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| **Economic Prosperity** | | | | | | | |
| *EP1. Benefits to Low- and High-wage Employment* | $382 | $441 | $555 | $431 | $370 | $1,060 | $1,380 |
| *EP2. Benefits to Cluster Employment* | $56 | $116 | $179 | $142 | $49 | $297 | $373 |
| *EP3. Benefits to Freight-Related Employment* | $55 | $86 | $97 | $81 | $52 | $171 | $226 |
| **Environmental Stewardship** | | | | | | | |
| *ES1. Vehicle and Stationary Emission Benefits* | -$14 | -$35 | $19 | $31 | $94 | $38 | $72 |
| *ES2. Impervious Surfaces* | ⊗ | - | - | ⊗ | ⊗ | - | - |
| *ES3. Agriculture and Natural Resource Lands* | ⊗ | - | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| *ES4. Energy Usage from Vehicle and Building Use* | ⊗ | ⊗ | + | + | + | + | + |
| **Quality of Life** | | | | | | | |
| *QL1. Accident Cost Savings* | -$94 | -$177 | -$52 | $1 | $168 | -$26 | $32 |
| *QL2. Nonmotorized Travel* | ⊗ | - | ⊗ | + | + | + | + |
| *QL3. Redundancy (Roads and Transit)* | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| **Equity** | | | | | | | |
| *E1. Geographic Distribution of Benefits* | + | ⊗ | + | - | ⊗ | ⊗ | ⊗ |
| *E2. Income Distribution of Benefits* | ⊗ | ⊗ | ⊗ | - | - | ⊗ | ⊗ |
| *E3. Benefits to Personal and Commercial Users* | ⊗ | ⊗ | ⊗ | - | - | ⊗ | ⊗ |
| *E4. Benefits to Environmental Justice Populations* | + | + | + | + | + | + | + |

All comparisons to the 2040 Baseline:
$$ in millions in the year 2040; positive values are benefits, negative values are costs; all monetary values are additive except for the Economic Prosperity benefits, which are benefits to a subset of the region.
⊗ is no significant change, - is negative change, + is positive change.

**FIGURE 3-2:** Evaluation Summary Table
(PSRC Transportation 2040, Appendix D, p.10)

### *Technical Attribute #3:*
### Impacts on the nonusers of planning options and projects are estimated

Vehicle emissions costs are the only direct nonuser impacts that are included in the BCA. Other nonuser impacts such as noise, vibration, and aesthetics are not included in the BCA.

### *Technical Attribute #4:*
### The approach accounts for indirect effects such as changes in local employment and land use

Examples of impacts that were not monetized directly by PSRC are equity and land use. Equity was explored in Transportation 2040 not as part of the central analysis, but as a sensitivity test run in response to requests from decision makers. PSRC was asked to report on whether benefits were equitably spread among users and nonusers in the region, with a special focus on areas of environmental justice concern.

*Environmental justice refers to Executive Order 12898, signed in 1994 by President Bill Clinton, stating that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations."*

PSRC addressed this request through two methods. By isolating the benefits for drive-alone, work trips in each of four income classes and by isolating the benefits to TAZs that contained higher percentages of low-income and/or minority populations than the region as a whole, and presenting the findings to decision makers. PSRC reported that isolation based on income-class proved unsuccessful but through the second analysis showed that TAZs with higher percentages of low-income and/or minority populations received the same as or higher benefits than the region as a whole. This finding suggests that the alternatives being considering are doing an adequate job addressing environmental justice issues. However, the environmental justice issue is subjective and the "adequate" level of benefits to certain population groups is something that is beyond the capabilities of a BCA. Land use is also not monetized, but the model does have the ability to measure changes in land use distribution.

### *Technical Attribute #5:*
### Interactions (synergies) between planning options are considered

Each PSRC build alternative encompasses multiple planning options. The options included in each alternative can be modified to observe synergies among various option combinations. However, for PSRC's BCA, options were not

analyzed, only the five alternatives. In the future, alternative modification scenarios could be analyzed to identify the optimal set of transportation improvements.

### *Technical Attribute #6:* The approach explicitly accounts for risk and uncertainty in forecasts and cost and benefit calculations

A level of uncertainty is involved in any analysis process, whether economic performance forecasts, model choice, or other key assumptions. The PSRC system allows the user to pick from a range of values for certain inputs. For example, the value of travel reliability can be modified depending on the uncertainty of travel time in the corridor being studied. Another example of a user-defined variable that can be adjusted is the cost per ton of pollutant. The expected value of fuel cost is a variable that must be adjusted in the model.

## Existing and Future Applications

According to PSRC, many aspects of the BCA tool will be refined with future applications. However, two aspects of refinement are prominent and relevant to potential applications in Oregon. First, PSRC is exploring how to use its tool to prioritize projects. The difficulty with doing this stems from inconsistency with the travel demand model used to analyze alternatives. As described earlier in this case study, the BCA tool is linked to PSRC's regional travel demand model. The tool can be used to assist decision making in the project development phase if analysis remains centered in the regional travel demand model. In reality, the analyses of many projects are often migrated to different platforms, depending on the lead agency. Transit capital projects in Seattle, for example, would use the Sound Transit ridership model. WSDOT-led projects would use WSDOT's travel demand model. City of Seattle-led projects would use its traffic model. Once the data have migrated to a different platform, the link to the BCA tool is broken and it is difficult to reliably migrate data back to PSRC. PSRC's travel model is currently used to evaluate scenarios in which multiple projects are combined. Transportation 2040 analyzes seven plan alternatives: a baseline alternative plus five action alternatives and the preferred alternative. The preferred alternative is a combination of the best performing transportation investments from each of the five action alternatives. Each

alternative includes transportation investments that will improve efficiency, expand the system's ability to handle future demand, support the region's goals for managing urban growth, and protect the environment. The preferred alternative was shown to have the highest BCR of any alternative analyzed.

A graphic summary of the alternatives is shown in Figure 3-3.

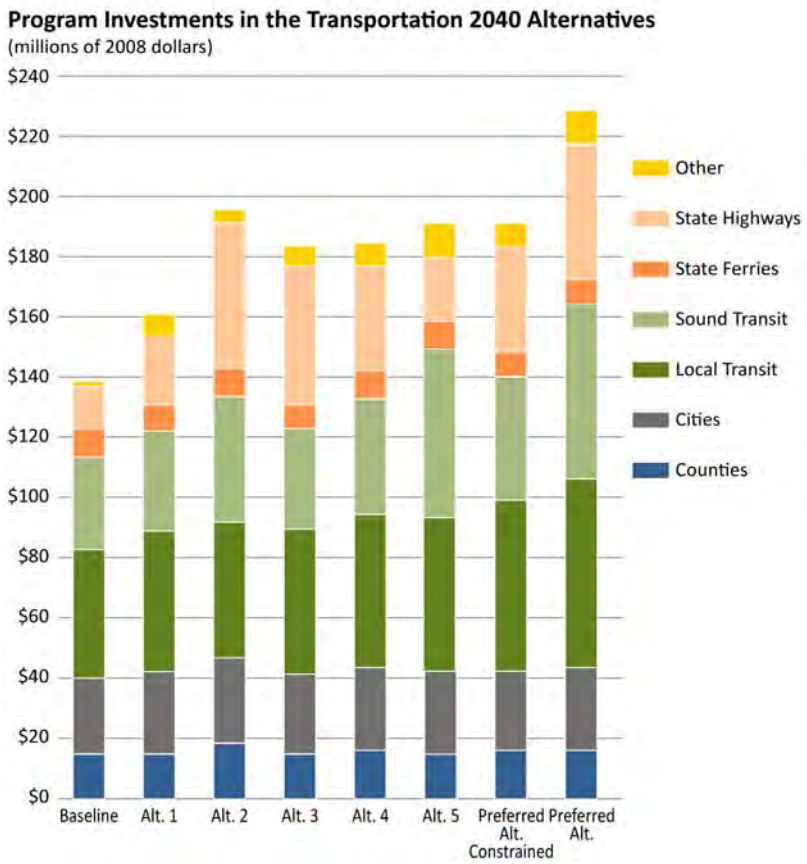


**FIGURE 3-3:** Program Investments in the Transportation 2040 Alternatives (Transportation 2040 FEIS, Exhibit 3-3)

If the platform remains with PSRC's travel demand model, the BCA tool can reasonably be used for alternatives analysis. However, most projects will migrate to models owned by separate agencies (such as a transit agency's ridership model or a city's travel model), in which case the link to the BCA tool will be broken. Most travel demand models in Oregon have a similar structure so this difficulty will be mitigated to a certain extent. However, effort early on to address this issue will ensure Oregon's BCA tool is able to work with data from all of Oregon's travel demand models. To be able to weigh the tradeoffs among project alternatives and prioritize project implementation, more effort must be made to apply the consumer benefit aspects of the model to *specific projects* in the future.

The second future step is to improve the linkage between the travel demand and the land use model. The Puget Sound's regional land use model, UrbanSIM, has been incorporated into PSRC's travel demand model, and the potential exists for exploring the indirect impacts of transportation investments on the built environment through this platform.

## United Kingdom Department for Transport NATA *Refresh*

NATA is a project-level multimodal evaluation framework administered by the UK Department for Transport (DfT). It is organized around the five goals of the government: environment, economics, safety, access, and integration. NATA combines information about a variety of evaluation factors within a single framework using a series of worksheets entitled "Appraisal Summary Tables (ASTs)." This framework evaluates the impacts and benefits of transportation investments (base case and alternatives). Much of the framework relies on monetizing the evaluation criteria using an extended benefit-cost platform. This platform, referred to as "BCA" elsewhere in this discussion paper, is referred to as a cost-benefit analysis (CBA) for the NATA *Refresh* case study to retain consistency with how it is referred to by the DfT. Other criteria are quantified in nonmonetized terms, while still others are evaluated on a qualitative level. The ASTs attempt to summarize benefits and impacts of a transportation investment in a clear, succinct manner for decision makers.

## Inception

NATA was first introduced in 1998. When the Labor government was elected, there was a push for a more comprehensive evaluation framework for projects. It was initially presented in the government's white paper "A New Deal for Transport." NATA's early focus was on: choosing among different alternatives to address project needs, identifying a way to prioritize alternate proposals, and assessing value for money (VfM) for each transportation investment. NATA serves as the basis for appraising multimodal studies as well as highway, rail, seaports, airports, and public transportation.

NATA *Refresh*, released in 2007, incorporates many environmental policies that were not addressed at the time of the original NATA in 1998. NATA *Refresh* was prompted, in part, by criticisms from the Eddington Transport Study[16] and the Stern Review,[17] which expressed that the original NATA didn't mesh well with the government's environmental policies. *Refresh* additions to the NATA BCA process include the following:

*Quantitative but not monetized information includes impacts where there is some valuation evidence but not enough to be included in the NATA assessment with confidence. Examples of these impacts include landscape, reliability, air quality, and journey ambience.*

- Incorporates the latest Department of Energy and Climate Change carbon dioxide ($CO_2$) valuations with the NATA guidance and software tools.
- Ensures alignment between local and national goals.
- Draws attention to adverse environment impacts, and provides evidence on adverse, often qualitative, impacts on a consistent and comparable basis.

## Technical Approach

NATA is a type of MCA wherein the appraisal summary provides information about *all* the impacts of the proposal, not just the monetary impacts. The CBA includes qualitative and quantitative information. A NATA assessment thus includes three kinds of information: some that are qualitative,

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16 The Eddington Transport Study was commissioned by the United Kingdom's Chancellor of the Exchequer and the Secretary of State for Transport and was published in 2006. Led by Sir Rod Eddington, the study focused on the economic and environmental impacts of transport decisions.

17 The Stern Review on the Economics of Climate Change was published in 2006 by Nicholas Stern of the London School of Economics. The focus of this study was the effect of global warming on the world economy and concludes that strong, early action to counter climate change greatly outweigh future costs.

some that are quantitative but not monetized, and some that is monetized. Quantitative but not monetized information includes impacts where there is some valuation evidence but not enough to be included in the NATA assessment with confidence. Examples of these impacts include landscape, reliability, air quality, and journey ambience. Combining these different types of information to evaluate alternatives and make decisions can be difficult. The AST combines all economic and environmental findings within one summary spreadsheet to support this decisionmaking process. Figure 3-4 illustrates an example of an AST.

The VfM process adds up all monetized assessments, augments the assessments with monetary evidence that is not robust enough for inclusion in the NATA guidance, and makes an educated judgment about the impact of the remaining impacts. The outcome is a statement of the overall VfM of the project based on the BCR:

- “Poor” value for the money if BCR is less than 1
- “Low” value for the money if BCR is between 1 and 1.5
- “Medium” value for the money if BCR is between 1.5 and 2
- “High” value for the money if BCR is between 2 and 4
- “Very High” value for the money if BCR is greater than 4

The “Very High” VfM category was added as part of NATA *Refresh* to encourage higher BCRs.

The final VfM value incorporates the qualitative impacts using a “backward induction” approach. This is a process of understanding how sensitive the VfM assessment is to negative or positive values of the factors that were scored qualitatively. In this way, NATA integrates qualitative and quantitative data in the final VfM assessment.

When there are numerous small-value positive and negative impacts, it can be difficult to decide whether the cumulative value is enough to change the assessment. This is a judgment that is left to the decision maker. The NATA analyst is encouraged to refer to previous assessments to ensure consistency in making this judgment.

NATA is generally applied on a project level and is applied to all DfT-led processes. It also is recommended for all projects that may eventually seek funding from the DfT.

**FIGURE 3-4:** Example AST
(UK DfT, Transport Analysis Guidance December 2004, pg. 6)

A11 Fiveways to Thetford Improvement –AST 20090919
**Appraisal Summary Table**

| **Option: Preferred Route** | **Description: On-line dualling with northern bypass of Elveden** | **Problems:** Congestion, particularly during holiday periods, conflict between long distance and slow moving agricultural traffic and limited overtaking opportunities lead to accidents. | **Present Value of Costs to Public Accounts £60.084m** |
|---|---|---|---|

| OBJECTIVE | SUB-OBJECTIVE | QUALITATIVE IMPACTS | QUANTITATIVE ASSESSMENT | ASSESSMENT |
|---|---|---|---|---|
| ENVIRONMENT | Noise | Properties near the existing A11 in Elveden will experience an overall significant noise decrease due to the significant reduction in traffic passing through the village. The facades of 7 properties which face the new A11 route towards the north of Elveden will see a noise increase greater than 5dB. Properties along the sections of existing route where there is no significant realignment will experience decreases in noise. This is because any increases in noise due to the increase in line speed are more than compensated for by the reduction in noise due to the thin surfacing.<br>Properties shielded by environmental screens will experience significant decreases | Estimated Population Annoyed without Scheme in 15th Year: 24<br>Estimated Population Annoyed with Scheme in 15th Year: 23<br>Net Noise Annoyance in 15th Year = -1 person<br>The number of properties experiencing noise levels in excess of 68 dB LA10,18h in the 15th year would reduce from 6 to 1 if the Scheme were implemented. | Net Present Value of Noise of Proposal = £66k |
| | Local Air Quality | The scheme has an overall beneficial impact, primarily due to realignment of the A11 around Elveden. There are no AQMAs in the study area and no new AQMAs will need to be declared as a result of the proposal. Concentrations are within the objectives in all future scenarios. | Air quality changes in $PM_{10}$: 141 properties experience improvement, 21 properties experience deterioration, 0 properties experience no change. Air quality changes in $NO_2$: 130 properties experience an improvement, 32 properties experience deterioration, 0 properties experience no change | $PM_{10}$ = -40.63<br>$NO_2$ = -184.32 |
| | Greenhouse Gases | The scheme results in a net increase in Carbon emissions over the 60 year appraisal period, compared to the Do-Nothing scenario. This is due to increased traffic volumes together with increased km travelled and higher speeds with the scheme. | Carbon Emissions change (tonnes) 60 year = 184,710. Opening yr = 642 | Net Present Value of Emissions (60 yrs) = - £6.026m |
| | Landscape | Impact on nationally unique Breckland landscape and Special Landscape Area / Area of Important Landscape Quality designations. Loss of important, visually characteristic, vegetation and impact on landscape character and patterns. The cutting in Mildenhall Woods impacts on the existing pattern of topography, creating a "notch" effect. Adverse impact on character and visual amenity at Weather and Horn Heaths, War Memorial and at cottages at Gate Lodge and Elveden Gap East, none of which can be mitigated. Improvement at Chalk Hall Farm. | Not Applicable | Moderate Adverse |
| | Townscape | Removal of A11 traffic from Elveden will result in marked improvement in appearance and amenity. | Not Applicable | Moderate Beneficial |
| | Heritage of Historic Resources | Impacts 34 known archaeological sites of Local to Regional significance; one slight adverse effect to a Roman settlement of Regional significance. All other archaeological impacts will be slight adverse or negligible effect. Possibility for further slight or neutral adverse effects on previously unrecorded sites which are most likely to be of Local to Regional significance if encountered. Significant improvement to Elveden CA and a slight improvement to How Hill Scheduled Monument. | Not Applicable | Slight Adverse |
| | Biodiversity | Structured and diverse planting would minimise effects to habitats and species along the route. Impacts to Breckland SPA and SSSIs would be mitigated via habitat creation at the Weeting Heath Extension. Impacts to Breckland SAC would be further mitigated by heathland restoration. The Scheme would benefit Rex Graham SAC/SSSI, great crested newts and the Cut Off Channel. New severance and fragmentation would affect habitats along the Elveden Bypass. Following proposed mitigation, overall score would be neutral. Natural England is in agreement with the proposals. | Not Applicable | Neutral |
| | Water Environment | A watercourse (the Cut Off Channel) & Major Aquifer are present. All potential impacts of the improvements on surface water quality and groundwater quality are reduced to neutral by pollution control measures. | Not Applicable | Neutral |
| | Physical Fitness | Some minor health benefits due to Elveden bypass & off-road path provision, but some minor adverse effects due to stopping up of some accesses. Light use of PRoW network. | Not Applicable | Neutral |
| | Journey Ambience | >10,000 travellers affected. Provides additional & retains traveller facilities. Overall traveller views are balanced. Less driver stress & frustration from congestion & fear of accidents is expected, due to 10m deer visibility zones & a central reserve. | Not Applicable | Large Beneficial |
| SAFETY | Accidents | Existing road is sub-standard single carriageway with limited opportunities for overtaking. Conflict with slow moving farm vehicles. Number of fatal accidents is in line with the national average for this standard of road. The scheme provides a higher standard road with lower accident rates which translates into a reduction in accidents over the life of the scheme. | Accident and Casualty Reductions.<br>Link Accidents: 889, Casualties: 1475<br>Junction Accidents: 20, Casualties: 39 | Scheme: Link PVB £99.298m<br>Junction PVB -£0.265m<br>Const/Maintenance -£6.592<br>Total PVB £92.441m |
| | Security | Those factors relating to safety are unchanged by the scheme. | Not Applicable | Neutral |
| ECONOMY | Public Accounts | The scheme will require public capital investment for construction. Tax revenues will be accrued over the life of the scheme equivalent to 41% of the investment cost. | Central Govt PVC: Operating Costs: £0.0m<br>Investment Cost: £101.989m<br>Indirect Tax Revenues: -£41.905m | PVC £60.084m |
| | Transport Economic Efficiency: Business Users & Transport Providers | Journey time savings accrue to users, due to reduced delays and higher operating speeds on the scheme. Vehicle operating costs are higher on the scheme primarily due to it be longer than the present route, reducing benefits by less than 2%. Construction and maintenance savings accrue, due primarily to maintenance travel time savings. | Users PVB £839.645m<br>Transport Providers PVB £0.000m<br>QUADRO PVB -£22.525 | PVB £817.120m |
| | Transport Economic Efficiency: Consumers | Journey time savings accrue to users, due to reduced delays and higher operating speeds on the scheme. Vehicle operating costs are higher on the scheme primarily due to it be longer than the present route, reducing benefits by less than 2%. Construction and maintenance savings accrue, due primarily to maintenance travel time savings. | Users PVB £424.487m<br>QUADRO PVB -£26.522m | PVB £397.965m |
| | Reliability | Reliability will improve due to a combination of increased capacity on the scheme and reduced accidents, leading to reductions in both incident related and day-to-day journey time variability. | Stress Values: Opening Yr - Do Nothing = 105 to Do Something =32 | Moderate Beneficial |
| | Wider Economic Impacts | Scheme promotes the dispersal of investment to the north-east of the East Anglian Region. No change in employment in a regeneration area. | Not Calculated | Neutral |
| ACCESSIBILITY | Option values | The scheme will result in no change to transport services available. | Not Calculated | PVB £m |
| | Severance | 2 PRoW positively affected – Elveden Byways 3 and 4. Usage of the PRoW network is low so impact is slight. Reduced severance in Elveden village due to the proposed bypass removing traffic from the village. | Not Applicable | Slight Beneficial |
| | Access to the Transport System | Access to road going transport facilities unchanged. Nearest railway east west through Thetford not affected by scheme. | Not Applicable | Neutral |
| INTEGRATION | Transport Interchange | Not relevant to this scheme | Not Applicable | Neutral |
| | Land-Use Policy | The scheme would support policies relating to the improvement of the road network and accessibility at regional and local level. However, it would have an adverse impact on policies aimed at protecting the environment at regional and local level. Nationally, PPG13 (transport) is supported overall. | Not Applicable | Neutral |
| | Other Government Policies | Policies on PPS1 (sustainable development), PPG15 (historic environment), PPG24 (noise) and PPS25 (flood risk) would be supported whereas PPS9 (biodiversity and geological conservation) and PPG16 (archaeology and planning) would be hindered. | Not Applicable | Beneficial |

NATA is not considered practical on a network scale. Delivering a Sustainable Transport System (DaSTS) is the DfT's ongoing attempt at network scale analysis in the form of a policy initiative. Preceding DaSTS was the policy initiative Towards a Sustainable Transport System (TaSTS) which was published in October 2007.

| APPLICATION OF LCP PRINCIPLES | | |
|---|---|---|
| **NO.** | **LCP Principle** | **Found in NATA *Refresh* Case Study?** |
| 1 | Multiple goals | ✓ |
| 2 | Oregon-specific policy goals | Partially |
| 3 | Demand management and other planning options | ✓ |
| 4 | Engagement of communities and decision makers | Partially |
| 5 | Useful basis for choice | ✓ |
| 6 | Project-specific or multiproject | Project |
| 7 | Has been used in decision support | ✓ |

Seven LCP principles (listed in Chapter 2 of this paper) were used as a basis for analyzing each case study. The paragraphs below describe how NATA *Refresh* addresses each principle category.

### *Principle #1:*
### The evaluation framework rolls up multiple goals

NATA *Refresh* uses these goals:

1. Environment
   a. Noise
   b. Local Air Quality
   c. Greenhouse Gases
   d. Landscape
   e. Townscape
   f. Heritage
   g. Biodiversity
   h. Water Environment
   i. Physical Fitness
   j. Journey Ambience
2. Safety
   a. Accidents

   b. Security

3. Economy
   a. Public Accounts
   b. Regeneration
   c. Transport User Benefits
   d. Reliability

4. Accessibility
   a. Option Values
   b. Severance
   c. Access to the Transport System

5. Integration
   a. Transport Interchange
   b. Land Use Policy
   c. Other Government Policies

Each of the above parameters of NATA *Refresh* also is aligned with goals of the DfT. In this sense, all projects evaluated with this methodology weigh the tradeoffs associated with multiple goals simultaneously. Because all findings are reported within an AST, tradeoffs among different goals and objectives are reported in a clear and transparent manner.

### *Principle #2:*
### The range of Oregon-specific transportation policy goals and objectives can be addressed

The NATA *Refresh* goals listed above align with Oregon-specific transportation policy goals as shown in Table 3-3.

**TABLE 3-3**
Oregon Transportation Plan Goals Compared to NATA *Refresh* Goals

| Oregon Transportation Plan Goal | NATA *Refresh* Objectives |
|---|---|
| Mobility and Accessibility | |
| Management of the System | |
| Economic Vitality | Economy |
| Sustainability | Environment |
| Safety and Security | Safety |
| Funding the Transportation System | |
| Coordination, Communication, and Cooperation | |

### *Principle #3:*
### A broad range of possible multimodal capacity, demand-management, land use, maintenance, and other planning options can be considered

The DfT issues demographic projections (population, households, workers, and jobs) for use in transportation planning. Most transportation investment analyses use these projections, and, in fact, a justification is required if they are *not* used. Projections are based on national-level trends, regional policy-based projections, and mechanistic methods for allocating to districts. Careful attention is paid to not overestimate demographic growth.

Though it is an area for future research, land use is analyzed, to an extent, through the land use policy NATA subobjective under the Integration goal. NATA gives advice on Land Use/Transport Interaction (LUTI) modeling, but the reliability of the models is of concern to the DfT. Many of the LUTI model parameters are based on subjective judgment. The LUTI model also projects demographic data and there is concern about the projections' relation to projections from the DfT. Further research is planned in the area of land use transportation planning.

### *Principle #4:*
### Members of the community and decision makers are engaged in the planning and decisionmaking process

The DfT leads development of NATA. Coordination among economists and other government divisions (such as the Department for the Environment and the Department of Energy and Climate Change) is extensive. Contractors are generally hired to develop the coefficients and parameters of the NATA *Refresh* guidance. These are then peer reviewed by a separate group of experts.

As described earlier, the NATA *Refresh* process was, in large part, a response to criticisms of NATA by sources such as the Eddington Transport Study and the Stern Review. These criticisms called for an update of NATA after 10 years of use and suggested that guidance be woven into new programs around sustainability (such as the policy goal "Delivering a Sustainable Transport System," or DaSTS).

All coefficients are entered through a public review period before they are used. When new NATA guidance is released, there is a period of time when the public has the opportunity to comment. The majority of public comments are from agencies and individuals who have used NATA in the past. According to the DfT, because the community of users is moderately small, the number of comments is manageable.

In summary, NATA stakeholders are almost exclusively technically trained. The tradition of stakeholder involvement common in Oregon is not comparable with stakeholder involvement in the UK. However, in the UK context, DfT has solicited and received broad comments from relevant agencies and constituencies.

### *Principle #5:*
### The approach facilitates the adoption of a meaningful, relevant, and operationally useful basis for choice

The DfT considers its NATA *Refresh* guidance to be effective in assisting with the balance and transparency in decision making. According to DfT, NATA is an evolutionary tool that becomes more effective with each new iteration, and helps expand analysis beyond what is typically considered.

It is important to note that, as with the PSRC system, the NATA process does not dictate projects to decision makers. Projects are generally scored within ranges that overlap. NATA enables the benefits and impacts across projects and alternatives to be compared to better inform decision makers' choices.

### *Principle #6:*
### The methodology can be applied at the project-specific level, and the collective (multiproject) level

NATA is generally applied on a project level and used for all DfT-led processes. Though not mandated for all projects, it is applied to all projects led by the DfT and its application on projects seeking funding from the DfT is strongly encouraged. DfT generally seeks strong justification when NATA is *not* used on a project.

NATA is not considered practical on a network scale, as demonstrated by the financially unsuccessful program of multimodal studies, started in 1998 and substantially

completed by 2004. Technically the program was reasonably successful but the expense and time consumption of the program, especially the transportation modeling, has prevented further multimodal studies from being conducted. DaSTS is the DfT's ongoing policy initiative attempt at appraisal on a network basis.

### *Principle #7:*
### The approach has been used for transportation planning

NATA is widely used throughout the UK to weigh transportation planning decisions.

| APPLICATION OF LCP TECHNICAL ATTRIBUTES | | |
|---|---|---|
| **NO.** | **LCP Technical Attribute** | **Found in NATA *Refresh* Case Study?** |
| 1 | Facilitates comparison of options | ✓ |
| 2 | Uses quantitative and qualitative evidence | Both |
| 3 | Considers impacts on nonusers | ✓ |
| 4 | Accounts for indirect effects | ✓ |
| 5 | Considers interactions and synergies | |
| 6 | Accounts for risk and uncertainty | ✓ |

Descriptions of the six technical attributes of LCP (also listed in Chapter 2 of this paper) in relation to the NATA *Refresh* example follow.

### *Technical Attribute #1:*
### Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units)

The VfM process sums all monetized assessments and augments these assessments with other quantitative and qualitative evidence to reach a judgment about project impacts. The principal outcome is a statement regarding the overall value for money invested based on the BCR.

According to the Spending Review 2004, 95 percent of approved spending was classified as offering "High" VfM. The "'Very High" VfM category was added in the 2009 *Refresh* to encourage higher BCRs.

### *Technical Attribute #2:*
### The approach makes use of quantitative and qualitative evidence

NATA's AST provides a summary report about *all* proposal impacts, not just those reported in monetary terms (see Figure 3-4). This aids incremental development of their methods. The criteria important to decision making are established first, and these can always be described in qualitative terms. As performance measures are developed, criteria can be evaluated in a quantitative or scalar manner. Finally, as criteria become monetized, they can be added to the VfM tool. Decision makers are advised to consider *all* findings reported on the AST, not just those that are quantified in monetary terms.

Ascertaining the final VfM value requires synthesizing the negative and positive qualitative impacts and understanding how sensitive the VfM assessment would be to varying degrees of these impacts. It is left to the decision maker to refer to previous assessments to ensure consistency in making this judgment.

### *Technical Attribute #3:*
### Impacts on the nonusers of planning options and projects are estimated

Hedonic pricing was used to monetize noise impacts. Property values were compared both before and after a source of noise was implemented to determine a monetary value of the effect of noise. NATA's CBA has also included monetary impacts of greenhouse gas levels since September 2006, although the value of these impacts change over time in line with advice from experts in the UK Department of Energy and Climate (DECC).

### *Technical Attribute #4:*
### The approach accounts for indirect effects such as changes in local employment and land use

NATA's CBA includes the monetized impacts on private sector providers' revenues and costs. However, it currently excludes monetary impacts on landscape, townscape, heritage of historic resources, biodiversity, water environment, physical fitness, and journey ambience.

### *Technical Attribute #5:*
### Interactions (synergies) among planning options are considered

Because NATA focuses on individual projects and alternatives, it is not structured to address the synergistic effects of packages of investments such as those addressed in the earlier case study on PSRC. DfT plans address this gap with further model refinement.

### *Technical Attribute #6:*
### The approach explicitly accounts for risk and uncertainty in forecasts and cost and benefit calculations

The current CBA accounts for risk in cost estimates through quantified risk assessment and optimism bias. DfT requires all proposals to include an allowance for optimism bias in cost estimates and requires a risk assessment for major (greater than £5m) projects at each key stage in the development of the proposal. Where risk assessment has been carried out, optimism bias adjustments are reduced.

Benefit projections account for risk through sensitivity testing. In the highway sector, high and low growth tests have been conducted in conjunction with sensitivity testing for significant local factors. Complex modeling is involved in benefit projection and, therefore, DfT recommends developing central, optimistic, and pessimistic scenarios rather than fully quantified risk analysis.

The ability to account for large unknowns such as policy uncertainty and climate change is something NATA is seeking to develop in the future.

## Existing and Future Applications

NATA is constantly being improved by the following:

- Reviews of the state of knowledge
- Monetization of additional impact topics
- Independent review of the impact estimates
- Public comment
- Demonstration project applications
- Wider use

NATA improvements are released as they are completed. The next steps include a focus on environmental factors such as

the value of reduced carbon emissions and of better air quality as determined by the DECC.

## Virginia Department of Transportation—VTrans2035

VTrans2035 is Virginia's current statewide long-range multimodal transportation plan. It was released in January 2010 as a collaborative effort among the Virginia Department of Transportation (VDOT) Office of Intermodal Planning and Investment in partnership with the Department of Rail and Public Transportation, Department of Motor Vehicles, and the Virginia Port Authority. The FHWA and regional planning bodies across the state also participated in its development.

### Inception

VDOT's primary contribution to LCP is its innovative, collaborative, and multimodal decision process to develop the statewide plan. The central end product from this collaborative process is the establishment of 11 CoSS. The CoSS, illustrated in Figure 3-5, describe needs and recommend solutions for *all* modes within a corridor—road, freight (truck and rail), public transportation (rail and bus), bicycle, and pedestrian. A central feature of VTrans2035 is its focus on access and mobility, bypassing potential bias towards any one mode.

**Figure 3-5:** Virginia's 11 Corridors of Statewide Significance (VTrans2035 Report to the Governor and General Assembly, Exhibit 12)

Virginia's collaborative multimodal transportation planning process is in its second generation. VTrans2035 builds upon its predecessor, VTrans2025. As is typical for state agencies, VDOT periodically updates its statewide plan, and VTrans2025 originally produced a series of recommended MINs. The selection of the 11 MINs involved a day-long meeting in 2005 in which representatives from transportation agencies across the state selected the corridors based on established criteria they had developed. VTrans2035 took the concept further, relabeling MIN as CoSS, expanding the description of needs, the scope of solutions, and establishing funding sources. VTrans2035, which began in Fall 2008, also vetted each of the 11 CoSS's through an extensive public review process. The resultant 11 corridors span all areas of the state, and attempt to address the needs of residents, business owners, freight business employees traveling through the state, and visitors.

## Technical Approach

The MIN process, established as part of VTran2025, combined projects from several modes into multimodal packages based on geographic corridors. In order to be designated as a MIN, a corridor had to meet four criteria:

- Have multiple modes or be an extended freight corridor
- Connect regions, states, and/or major activity centers
- Provide for a high volume of travel
- Provide a unique statewide function and/or address statewide goals

With VTrans2035, a group of decision makers representing four modal agencies within VDOT—highways, rail, marine, and public transportation—took part in identifying deficiencies, brainstorming potential solutions, evaluating solutions, and selecting recommendations. While one modal agency took the lead in championing each MIN, all the agencies participated in identifying and evaluating multimodal needs. This represented a shift from focusing on individual modal capacity issues to focusing on the most efficient way to move people and goods throughout the state. The result—VTrans2035—produced a more integrated transportation system that features multimodal solutions. The multimodal needs of each of 11 corridors were identified and solutions to meet those needs were presented as part of VTrans2035.

The key LCP principles employed in VDOT's development of VTrans2035 include:

- Assess multiple goals
- Include demand-management and other planning options
- Engage communities and decision makers
- Use results to inform decision making

The multimodal planning practices were "modally blind." The planning process evaluated the merit of all modes on an equal footing and was not biased toward any particular mode. Further, all modes were analyzed simultaneously, and interactions between modes were examined.

The paragraphs below describe how VTrans2035 addressed each of the seven principles.

**APPLICATION OF LCP PRINCIPLES**

| NO. | LCP Principle | Found in VTRANS2035 Case Study? |
|---|---|---|
| 1 | Multiple goals | ✓ |
| 2 | Oregon-specific policy goals | Partially |
| 3 | Demand management and other planning options | ✓ |
| 4 | Engagement of communities and decision makers | ✓ |
| 5 | Useful basis for choice | |
| 6 | Project specific or multiproject | Multiproject |
| 7 | Has been used in decision support | ✓ |

### *Principle #1:*
### The evaluation framework rolls up multiple goals

The goals of VTrans2035 are:

- *Safety and Security* – to provide a safe and secure transportation system.
- *System Maintenance and Preservation* – to preserve and maintain the condition of the existing transportation system.
- *Mobility, Connectivity, and Accessibility* – to facilitate the easy movement of people and goods, improve

interconnectivity of regions and activity centers, and provide access to different modes of transportation.

- *Environmental Stewardship* – to protect the environment and improve the quality of life for Virginians.
- *Economic Vitality* – to provide a transportation system that supports economic prosperity.
- *Coordination of Transportation and Land Use* – to promote livable communities and reduce transportation costs by facilitating the coordination of transportation and land use.
- *Program Delivery* – to achieve excellence in the execution of programs and delivery of service.

The identification of needs, development of potential solutions, and selection of recommended program improvements all balanced the goals and objectives listed above. VDOT established measures to compare how multimodal packages of alternatives performed in relation to each of the plan's goals. These were then evaluated by decision makers to weigh the tradeoffs between high performance in some areas and lower performance in others.

### *Principle #2:*
### The range of Oregon-specific transportation policy goals and objectives can be addressed

The VTrans2035 goals listed above align with Oregon-specific transportation policy goals as shown in Table 3-4.

**TABLE 3-4**
Oregon Transportation Plan Goals Compared to VTrans2035 Goals

| Oregon Transportation Plan Goal | VTrans2035 Goals |
|---|---|
| Mobility and Accessibility | Mobility, Connectivity, and Accessibility |
| Management of the System | System Maintenance and Preservation |
| Economic Vitality | Economic Vitality |
| Sustainability | Environmental Stewardship |
| Safety and Security | Safety and Security |
| Funding the Transportation System | |
| Coordination, Communication, and Cooperation | |

VDOT and ODOT share many common goals for its statewide planning efforts. This is found throughout VTrans2035 where the focus is on preserving the existing system, strengthening the economy, maximizing safety, and minimizing impacts to the built and natural environment. Although funding and coordination were not specifically listed as goals of VTrans2035, their extensive coordination is notable, and the statewide plan featured a chapter on financing the system. The VTrans2035 network was not fiscally constrained.

### *Principle #3:*
### A broad range of possible multimodal capacity, demand-management, land use, maintenance, and other planning options can be considered

VTrans2035 consideration of multimodal capacity, demand management, land use, and maintenance are addressed below:

- *Multimodal capacity* – All decisions for VTrans2035 (identification of needs, brainstorming solutions, and selecting recommendations) were done with all modal divisions in VDOT collaboratively, in a manner that did not give preference to one mode over another.
- *Demand-management* – The Department of Rail and Public Transit has led efforts to coordinate, plan and implement transportation demand management (TDM) programs (for example, carpooling, vanpooling, and teleworking) in the Commonwealth, along with local and regional partners. TDM measures can be cost effective in managing travel demand by moving more people in fewer vehicles, moving trips out of peak period, or eliminating trips altogether.
- *Land Use* – Land use impacts are not explicitly built into the process.
- *Maintenance* – Maintenance is included in the 6-year operations spending category. This ultimately factored into Virginia's BCR for all planned projects in the state over the next 6 years.

### *Principle #4:*
### Members of the community and decision makers are engaged in the planning and decisionmaking process

The community was involved in the CoSS selection process in VTrans2035 through public comment and outreach typical to a state or regional planning effort. The outreach efforts consisted of:

*Stakeholder Listening Sessions,* where 32 stakeholders from around the state were asked to help brainstorm issues and provide input on key statewide initiatives. The list of stakeholders included: AAA of Virginia, Richmond Area Bike Association, Northern Virginia Transportation Alliance, Virginia Chamber of Commerce, Virginia Chamber of Counties, Virginia Chapter of the American Planning Association, AARP, Virginia Transit Association, Virginia Tourism Corporation, Virginia Department of Aging, AAA of Virginia, Virginia Maritime Association, Virginia Economic Development Partnership, Bike Walk Virginia, Southern Environmental Law Center, Virginia Airport Operator's Council, Washington Airports Task Force, Virginia National Defense Industrial Authority, Virginia Transportation Construction Alliance, Virginia Bicycling Federation, Virginia Department of Conservation and Recreation, Dominion Virginia Power, Virginia Rail Association, VRE, Fairfax County DOT, Wilbur Smith Associates, Vanasse Hangen Brustlin, Virginia Department of Transportation, Virginia Department of Aviation, Virginia Department of Rail and Public Transportation, Virginia Department of Motor Vehicles, and Virginia Port Authority.

- *Regional Planning Forum,* where staff and key stakeholders were asked to help VDOT prepare the vision for VTrans2035, and develop potential strategies
- *Public Meetings* (four held in different areas around the state, one virtual meeting held on the project website), where members of the public were asked for feedback on the draft CoSS, and to help establish priorities
- *VTrans2035 Forum,* where the public was asked for input on the draft plan and its priorities.

In addition, VTrans2035 had a Multimodal Advisory Committee composed of key agency staff that met periodically (monthly or bimonthly) through the process to provide

guidance. This committee established subcommittees on land use; asset management; freight; mobility, connectivity, and accessibility; economic development; congestion; European lessons; regional and local decision making; and safety. A group of decision makers, a subcommittee of Commonwealth Transportation Board (CTB) members, met twice during the process at key milestones to approve criteria and to approve recommendations.

### *Principle #5:*
### The approach facilitates the adoption of a meaningful, relevant, and operationally useful basis for choice

The study "Economic Impact of Transportation Investments in Virginia" was conducted in parallel with VTrans2035 and produced a BCR of 4.0 to 1 associated with planned transportation infrastructure improvements in Virginia from 2009-2014. Since the study was conducted in parallel with VTrans2035, the study itself was not used to decide which improvements were included in the list of recommendations. Rather it was used to determine whether the VTrans2035 recommendations as a whole would be a wise investment of state, federal, and local funds.

However, the VTrans2035 process had at its center a strong, multi-criteria decisionmaking process that engaged all modal divisions. As described earlier in this case study, this meant that public transportation, highway, freight, and ports jointly determined needs and evaluated alternatives. In this sense, the VTrans approach, though not a specific monetization of impacts and benefits, did focus on a meaningful and relevant decision process.

### *Principle #6:*
### The methodology can be applied at the project-specific level, and the collective (multiproject) level

Although consisting of bundles of individual projects, VTrans2035 does not make project specific recommendations. Instead, it highlights each of the 11 CoSS and makes larger program recommendations for the state. Each CoSS is multimodal and may include such facilities as: roadway capacity projects, rail line upgrades or new infrastructure, new or added rail or bus transit services, port facilities, and

airports. Parallel roadway facility improvements are also included in addition to the main Interstate or U.S. Highway.

CoSS identification criteria were developed by technical advisors representing rail, transit, highway, aviation, port, MPO, and Planning District Commission (PDC) interests. The criteria were then applied to aid in identifying the 11 CoSS. Each CoSS satisfies all of the following four criteria:

1. *Multimodal* – must involve multiple modes of travel or be an extended freight corridor.
2. *Connectivity* – must connect regions, states, and/or majority activity centers.
3. *High Volume* – must involve a high volume of travel.
4. *Function* – must provide a unique statewide function and/or address statewide goals.

### *Principle #7:* The approach has been used for transportation planning

Return on investment and BCR were used by decision makers to justify use of tax dollars for the proposed 6-year transportation plan. The justification for use of expenditures was then defined in terms of added employment, business outputs, cost savings from reduced travel times (both freight and commute), and worker incomes.

The CoSS is just one source of information used to make funding decisions. VTrans2035 has identified four Investment Priority Groups that each encompasses multiple investment priorities. The priorities of the CoSS are represented in these investment priorities (see Figure 3-6).

| APPLICATION OF LCP TECHNICAL ATTRIBUTES | | |
|---|---|---|
| NO. | LCP Technical Attributes | Found in VTrans2035 Case Study? |
| 1 | Facilitates comparison of options | ✓ |
| 2 | Uses quantitative and qualitative evidence | Predominantly Qualitative |
| 3 | Considers impacts on nonusers | ✓ |
| 4 | Accounts for indirect effects | |
| 5 | Considers interactions and synergies | ✓ |
| 6 | Accounts for risk and uncertainty | |

**Figure 3-6:** VTrans2035 Investment Priorities (VTrans2035 Report to the Governor and General Assembly, Exhibit 29)

| Investment Priority Group | Investment Priority | Preliminary Planning Estimate of Unfunded Need (2009$)** |
|---|---|---|
| Make Strategic Investment in Infrastructure for the Future – For Example* (Total Need) | Plan for and Invest in High Speed Rail or Intercity Rail Between Washington, D.C., Richmond, and Hampton Roads and Expand Metrorail and/or Commuter Rail, Including Supporting Land Uses, in the I-95 Corridor | $3.4 - $5.5 Billion |
| | Freight Rail Along I-81 | $0.8 - $1.2 Billion |
| | Tunnels and Bridges in Hampton Roads | $7.8 - $11.3 Billion |
| | Smart System Technology Leadership | $2.2 - $3.1 Billion |
| Address Environmental, Safety, and Maintenance Needs | Use Sustainable and Environmentally Sensitive Methods | Varies Depending on Project and Criteria |
| | Provide Safe Operations and Services | $184 - $258 Million/Year |
| | Repair Deficient Pavements | $278 - $389 Million/Year |
| | Rehabilitate Structurally Deficient Bridges | $150 - $210 Million/Year |
| | Ensure State of Good Repair in Transit | $148 - $207 Million/Year |
| Enhance Economic Competitiveness (Total Need) | Expand the Port and Related Intermodal Facilities and Services | $7.7 - $11.0 Billion |
| | Support Dulles International Airport and Growth of the Dulles Corridor | $1.7 - $2.5 Billion |
| | Connect High Speed and Intercity Rail with Regional Transit Systems | $2.8 - $4.0 Billion |
| | Improve Freight Mobility | $14.1 - $20.5 Billion |
| | Improve Rural Connectivity | Varies Depending on Project |
| | Complete Unfinished PPTAs and Review and Refine PPTA Process to Effectively Leverage Private Dollars for Publicly Beneficial Projects | $3.8 - $5.8 Billion |
| | Develop Master Plans for Needs of Corridors of Statewide Significance | Utilize Existing Intermodal Funds |
| Minimize Congestion | Integrate Regional Land Uses and Highway Capacity | Requires a Dedicated Funding Source |
| | Implement Pricing, Advanced Technology, and Demand Management | Requires a Dedicated Funding Source |
| | Increase Transit Usage and Supporting Land Uses | $128 - $143 Million/Year |

*There are several examples of crucial game-changing infrastructure investments. These four are offered as examples because of their potential impacts on both a regional and statewide basis.
**Unfunded needs are preliminary order-of-magnitude planning estimates and are subject to revision as additional information becomes available. Estimates are in 2009 dollars; the range of costs reflects allowance for contingencies. The priorities should not be summed because some improvements are included in more than one priority. For example, the Third Crossing is included in three priorities: Tunnels and Bridges in Hampton Roads; Expand the Port; and Improve Freight Mobility.

The six technical attributes of LCP (also listed in Chapter 2 of this paper) in relation to VTrans2035 are described below.

### *Technical Attribute #1:*
### Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units)

The decisions made through the VTrans2035 process were based on a mixture of quantitative and qualitative evidence,

including all decision-points, although little information was converted into monetary terms. The exception to this is the BCR efforts conducted separate from the decision process for the recommended program improvements in VTrans2035, which was done only for items that can be measured monetarily. Decision making in VTrans2035 was done using a multi-criterion analysis. The BCR was only reported for the recommended suite of improvements, for the entire state as a whole.

### *Technical Attribute #2:*
### The approach makes use of quantitative and qualitative evidence

As stated above, much of VTrans2035's decisions were based on a mixture of quantitative and qualitative evidence, including all decision-points. Quantitative evidence was used in the BCA analysis to determine feasibility of the transportation investment budget across the state.

Quantitative evidence included short-term spending impacts and long-term improvement impacts. Determination of these impacts for the economic impact study was a three-step process. First, spending was estimated for the 6-year time period of 2009-2014 based on the "Commonwealth Transportation Fund Allocation Summary." Second, the impact of this spending on transportation facility capacity, use, and conditions were analyzed. Finally, the Transportation Economic Development Impact System (TREDIS) economic model was applied to estimate overall impacts on the Virginia economy. These impacts were then used to calculate the BCR for all planned transportation investments across the state.

### *Technical Attribute #3:*
### Impacts on the nonusers of planning options and projects are estimated

Impacts on nonusers are accounted for through the number of jobs created, business added, and increased worker income due to the transportation investments planned for 2009-2014. This information comes from TREDIS output.

### *Technical Attribute #4:*
### The approach accounts for indirect effects such as changes in local employment and land use

Indirect effects are not included in VTrans2035.

### *Technical Attribute #5:* Interactions ("synergies") among planning options are considered

By definition, the economic impact analysis considered synergies by bundling the different modal projects in the 11 corridor packages. No sensitivity testing of removing individual projects to rate its effect on the value of the bundle as a whole was conducted.

### *Technical Attribute #6:* The approach explicitly accounts for risk and uncertainty in forecasts and cost and benefit calculations

The BCA conducted on the set of 11 corridors did not explicitly account for uncertainty.

TREDIS allows for a range of values associated with costs and benefits of particular impacts. The user can adjust these values as they see fit. However, since VDOT used the default values provided, it cannot be said that the approach accounts for risk and uncertainty.

## Existing and Future Applications

VDOT is now embarking on an effort to develop corridor specific reports for each CoSS. These reports will refine needs specific to that corridor, specify investments needed, and continue to collaborate among divisions within VDOT to assure all modes are considered and addressed.

In addition, VDOT has future plans to continue and expand use of its economic analysis capabilities. The specific elements of this initiative include:

- *Projects and Programs* – VDOT, in its upcoming work program, will evaluate the economic impacts of individual projects and subset of project groupings to weight the unique benefits and impacts when compared to other alternatives and groupings of projects.
- *Freight and Passenger Impacts* – VDOT will focus on distinguishing freight from passenger impacts and benefits in order to better reflect differences in freight and passenger mix among airport, marine port, rail, road and bus-oriented efforts.

- *Rural and Urban Impacts* – being a state agency, the ability to assess access, congestion, and connectivity impacts differently for urban as opposed to rural areas is important to VDOT and is the focus of future analysis.
- *Peak and Off-Peak Effects* – VDOT will conduct work to identify seasonal and time-of-day differences in service levels and congestion.

## Central Indiana Transit Task Force Central Indiana Transportation Plan

In 2008, the Central Indiana Transit Task Force (CITTF) retained a team of consultants to conduct a value-driven, stakeholder-engaged regional planning process based on least cost and value-maximizing planning principles.

The task force was composed of the Central Indiana Corporate Partnership (CICP), the Greater Indianapolis Chamber of Commerce (GICC), and the Central Indiana Community Foundation (CICF), organizations representative of business and industry in the region; as well as ex-officio representation from the Indianapolis Metropolitan Planning Organization (IMPO), the Central Indiana Regional Transportation Authority (CIRTA), the Indianapolis Bus Corporation (IndyGo), and the Indiana Department of Transportation (INDOT).

The task force's mission was as follows:

> "Develop and present the Private Sector's preferred comprehensive regional transportation strategy for the nine-county Central Indiana Region that has a:
>
> - Medium- to long-term planning horizon;
> - Scope, cost, and value easily understood by general public;
> - Realistic funding options, capable of earning broad public support;
> - Execution strategy capable of beginning implementation in the near future; and
> - Plan to gain consensus among stakeholders, policy makers and the general public."

## Inception

The task force determined that—while a great deal of solid technical study and discussion had occurred in the Central Indiana Region over the past decade—no real political consensus had evolved around how the region should pursue its transportation future. There had been no clear agreements on the appropriate roles and mixtures of roadway investment, bus, rail, and other forms of transportation enhancements. This caused the region to continue with the status quo in terms of transportation investment, which was perceived by some as inadequate for tackling growing congestion and environmental concerns.

## Technical Approach

More than 30 regional planning scenarios were considered, with each scenario representing a different combination of highway, transit, and demand management projects and policies, including express lanes, alternative bus routings, and rail alignments. Scenarios were defined through a detailed planning process that adhered to three core principles:

1. Each scenario was defined for the region as a whole.
2. Each scenario represented a solution that was both subarea-specific and operationally compatible and consistent across all subareas.
3. Each scenario represented a “realistic plan” to respond to congestion, travel demand, and development patterns and opportunities.

Using a comprehensive benefit-cost analysis framework, the team estimated the life-cycle costs and benefits of each planning scenario relative to various goals, including safety, mobility, congestion management, environmental sustainability, livable community development, and regional economic development (macroeconomic effects on employment, output and income). In addition, the analysis examined the regional and social distribution of benefits and costs, and explored a wide range of financing options and their affordability.

The team facilitated a stakeholder engagement process to: validate the definition of planning scenarios; review all technical assumptions, including the economic and social values used in the monetization of benefits and costs; and

evaluate the alternatives according to Net Present Value criteria.

Through facilitation and risk analysis, the task force achieved consensus on a recommendation to be communicated to the nine-county Region's general public. The recommendation constitutes a combination of demand management (congestion pricing) initiatives, a range of highway improvements, a large-scale improvement in the region's bus network, and major investments in light rail and commuter rail.

| APPLICATION OF LCP PRINCIPLES | | |
|---|---|---|
| NO. | LCP Principle | Found in Central Indiana Transportation Plan |
| 1 | Multiple goals | ✓ |
| 2 | Oregon-specific policy goals | Partially |
| 3 | Demand management and other planning options | ✓ |
| 4 | Engagement of communities and Decision makers | ✓ |
| 5 | Useful basis for choice | ✓ |
| 6 | Project-specific or multiproject | Multiproject |
| 7 | Has been used in decision support | ✓ |

Seven LCP principles (listed in Chapter 2 of this paper) were used as a basis for analyzing each case study. The paragraphs below describe how the consulting team commissioned by the task force addressed each of these principles.

### *Principle #1:*
### The evaluation framework rolls up multiple goals

The primary objective of the task force was to develop a transportation plan for Central Indiana that would:

- Improve the mobility of the workforce.
- Improve the quality of transit services and offer more transportation choices.
- Improve the mobility of low-income households.
- Reduce roadway congestion.
- Contain suburban sprawl and strengthen the regional core.
- Promote urban forms that help attract and retain young workers.

- Achieve environmental compliance with federal air quality standards.
- Be based on realistic funding options, capable of earning broad public support.

The consulting team first identified benefit metrics for each of the goals listed above. Examples of metrics included travel time savings, emission cost savings, changes in residential and commercial property values, or increased trip-making by low-income households. The team then sought to monetize as many of these benefits as possible.

Monetized benefits (and costs) were estimated over a 30-year planning horizon and were aggregated by summation, to arrive at standard BCA summary measures (for example, Net Present Value, Benefit/Cost Ratio, or Internal Rate of Return). Other nonmonetized impacts were described qualitatively.

### *Principle #2:*
### The range of Oregon-specific transportation policy goals and objectives can be addressed

The goals set forth by the task force were more specific than those outlined for Oregon; they applied to a region (Central Indiana) as opposed to an entire state. Table 3-5 demonstrates that the two sets of goals are nonetheless well aligned.

**TABLE 3-5**
Oregon Transportation Plan Goals Compared to CITTF Goals

| Oregon Transportation Plan Goal | CITTF Goals |
|---|---|
| Mobility and Accessibility | Improve the quality of transit services and offer more transportation choices; improve the mobility of low-income households; reduce roadway congestion |
| Management of the System | |
| Economic Vitality | Improve the mobility of the workforce; contain suburban sprawl and strengthen the regional core; promote urban forms that help attract and retain young workers |
| Sustainability | Achieve environmental compliance with federal air quality standards |
| Safety and Security | |
| Funding of the Transportation System | Propose realistic funding options, capable of earning broad public support |
| Coordination, Communication, and Cooperation | |

### *Principle #3:*
### A broad range of possible multimodal capacity, demand-management, land use, maintenance, and other planning options can be considered

The options considered in the planning process can be grouped within two broad categories: core scenarios and blended (or mixed) scenarios.

The core scenarios were defined as planning options focusing on a single mode or strategy: roadway expansion, congestion pricing, and new or expanded transit services. The core scenarios were developed first, through the following process:

Identify investments or initiatives that have already been committed (the "base case"):

- assess additional investment opportunities in each corridor or subarea within the region, on the basis of travel demand projections and existing and future land use; and
- identify the value maximizing option for each corridor or subarea.

The three core strategies (roadway expansion, congestion pricing, and new or expanded transit services) were "optimized" independently, and then combined into packages of regional alternatives for evaluation. The logic through which regional alternatives were identified is illustrated in Figure 3-7. The tree begins with congestion pricing (yes or no) and branches out into different generically defined regional mixes of highway and transit investments.

The planning options were compared and ranked on the basis of benefit-cost analysis in order to identify an "optimized" regional alternative. For example, the "optimized" congestion pricing alternative was drawn from the benefit-cost analysis of different possible congestion pricing options such as high-occupancy/Toll (HOT) lanes in select locations or corridor-wide pricing. Similarly, the high capacity transit strategic alternatives were drawn from a benefit-cost analysis of different region-wide combinations of transit modes.

The blended scenarios were then defined as a combination of the top-ranking core scenarios. More precisely, the blended scenarios were composed of the two or three core scenarios

that performed best in the benefit-cost analysis conducted within each core category.

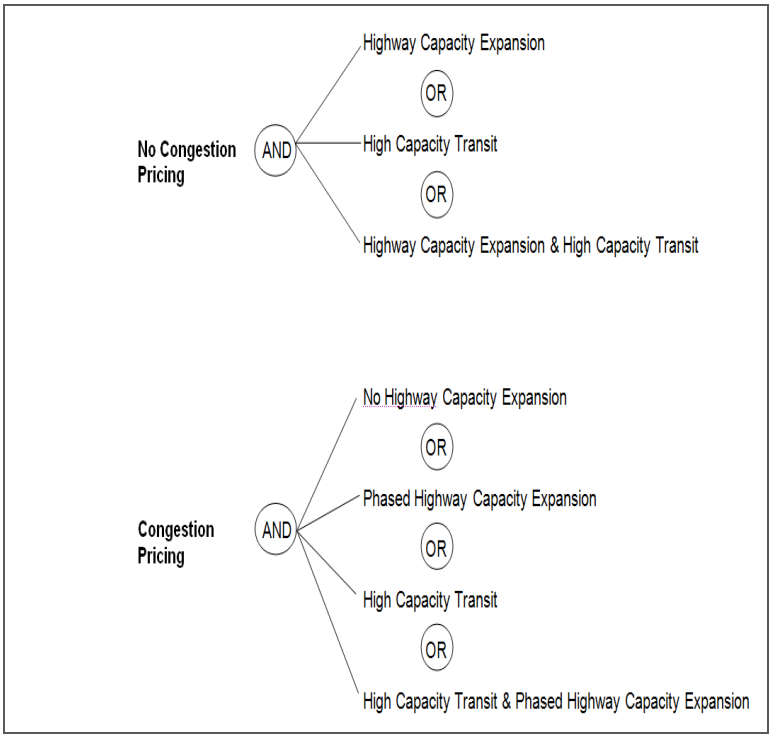


**FIGURE 3-7**: Decision Tree for Identifying Regional Alternatives

### *Principle #4:*
### Members of the community and decision makers are engaged in the planning and decisionmaking process

The planning process involved the facilitation of a series of workshops during which representatives from the task force and other regional stakeholders were invited to comment and provide input on the methodology, estimating assumptions, and findings to date.

Structure and logic diagrams depicting how data elements and parameter values were combined to arrive at estimates of both costs and benefits were displayed during the workshops, which allowed for scrutiny and potential modifications. Workshop participants were invited to add variables and hypothesized causal relationships that may be material and missing from the proposed model. An example of a structure and logic diagram is provided in Figure 3-8.

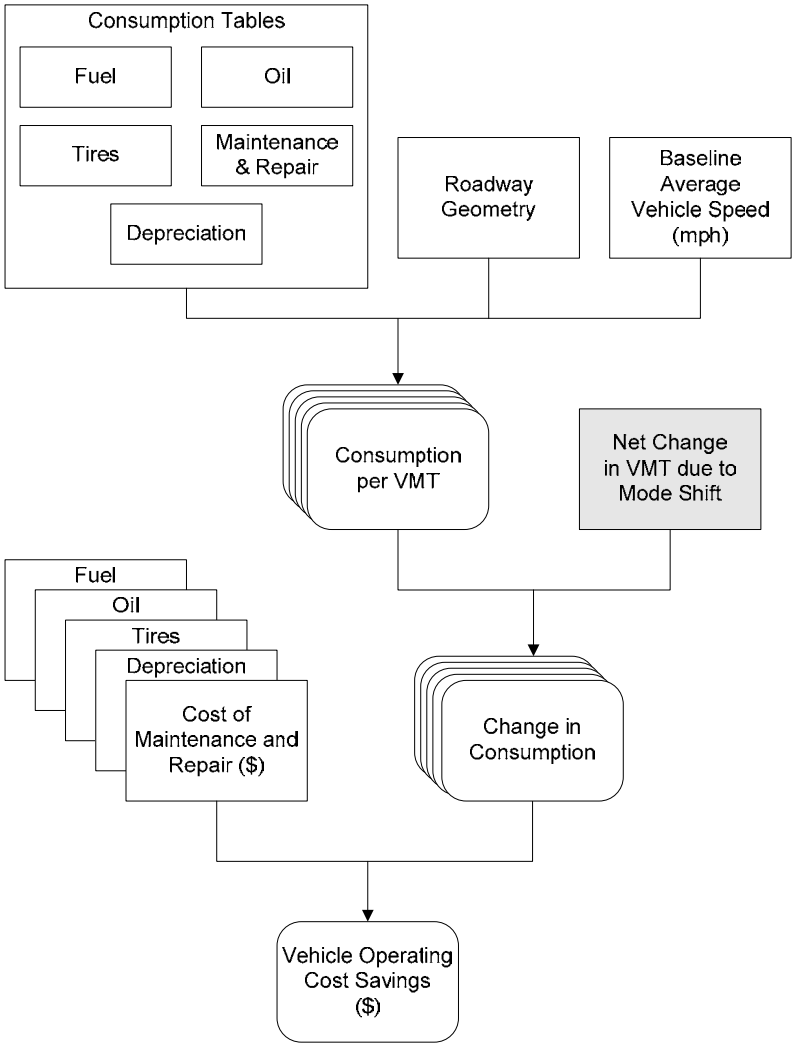


**FIGURE 3-8:** Example of a Structure and Logic Diagram, Estimation of Vehicle Operating Cost Savings from Modal Shifts

Workshop participants were also invited to review and comment on some of the social and economic values selected by the research team to monetize impacts. Special data sheets were used to record input. In addition to commenting on a central-most likely value, panelists were encouraged to provide a range of possible values reflecting their probability beliefs about the uncertainty associated with the variable or assumption. An example data sheet is provided in Table 3-6.

**TABLE 3-6**
Example of a Data Sheet, Value of Time

| | Units | Most Likely | Low | High |
|---|---|---|---|---|
| Auto (average across all trip purposes) | $ per hour | $12.5 | $9.9 | $14.9 |
| Heavy trucks | $ per hour | $44.3 | $35.4 | $53.1 |

### *Principle #5:*
### The approach facilitates the adoption of a meaningful, relevant and operationally useful basis for choice

All planning scenarios were compared and ranked according to Full Cost Net Present Value (discounted benefits minus discounted costs, when accounting for all costs) and Full Cost Internal Rate of Return (rate of return based on all costs). Additional summary metrics were developed and reported as well, including:

- *Full Lifecycle Costs* – discounted capital and operation and maintenance (O&M) costs over-and-above current IndyGO and highway maintenance expenditures, including estimated local and federal shares.
- *Local Cost NPV* – discounted benefits minus discounted local share of costs.
- *Local Cost IRR* – rate of return based on local costs.
- *Local Lifecycle Costs* – discounted capital and O&M costs over-and-above current IndyGO and highway maintenance expenditures, including estimated local share only.
- *Local Incremental Capital Cost* – undiscounted value of local share of capital costs relative to current highway spending plan.
- *Average Annual Local Incremental O&M After Revenues* – undiscounted value of local share of operations and maintenance costs relative to current highway spending plan after deducting the average annual incremental system revenues from the transit and express lane systems.

- *Return on Incremental Capital* – rate of return on the incremental investment relative to the current highway spending plan and the benefits of that plan.
- *Percentage of Benefits Outside Marion* – proportion of total benefits generated outside of Marion County (where Indianapolis is located).
- *Lifecycle Benefit* – discounted value of benefits to society.

Finally, some of the impacts estimated as part of the planning process were not rolled up into the above metrics. The effects of the proposed planning options on regional employment, output, and income, for example, were reported separately.

### *Principle #6:*
### The methodology can be applied at the project-specific level, and the collective (multiproject) level

As we have seen, the life-cycle costs and benefits of each planning option were estimated within a comprehensive benefit-cost analysis framework. While each scenario included multiple projects, the methodology and models developed by the team are scalable and can be—and have been—applied at the project level as well.

### *Principle #7:*
### The approach has been used for transportation planning

In addition to this specific application, a similar process was used for transportation planning in the Greater Cincinnati Area and the Greater Toronto and Hamilton Area. In none of these applications, however, were as many planning options considered and evaluated as in Central Indiana.

**APPLICATION OF LCP TECHNICAL ATTRIBUTES**

| NO. | LCP Technical Attribute | Found in Central Indiana Case Study? |
|---|---|---|
| 1 | Facilitates comparison of options | ✓ |
| 2 | Uses quantitative and qualitative evidence | Predominantly Quantitative |
| 3 | Considers impacts on nonusers | ✓ |
| 4 | Accounts for indirect effects | ✓ |
| 5 | Considers interactions and synergies | ✓ |
| 6 | Accounts for risk and uncertainty | ✓ |

The six technical attributes of LCP (also listed in Chapter 2 of this paper) in relation to the Central Indiana Transportation Plan are described below.

### *Technical Attribute #1:*
### Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units)

As discussed in Chapter 2 and in the PSRC case study, one of the main strengths of benefit-cost analysis is its ability to synthesize multiple effects—costs or benefits—into a single metric or a limited set of metrics (the benefit/cost ratio or net present value) through monetization. These metrics can then be used to rank or compare planning options, as was done in Central Indiana. Effects that cannot be monetized are typically described separately, for consideration in decision making.

The following benefits were reported in monetary-equivalent units in the evaluation of planning options for Central Indiana: travel time savings; vehicle operating cost savings; emission cost savings ($CO_2$ and criteria air contaminants); safety benefits; budgetary savings to low-income users; the option and amenity value of improved transportation choice (community livability benefits); and increased employment and output. Monetized costs included capital outlays, changes in annual O&M expenditures and a measure of "financial" cost (the opportunity cost of capital, as reflected in the discount rate).

### *Technical Attribute #2:*
### The approach makes use of quantitative and qualitative evidence

The evaluation focused on quantitative and monetized impacts. Quantitative effects that could not be monetized were reported where needed (e.g., number of jobs created); and effects that could not be quantified at all were described qualitatively. This implied that the policy goals set forth by the task force (and region) were weighted exclusively through monetary valuation: there was no attempt by the consulting team to weigh nonmonetized impacts, as is sometimes done in MCA or goal achievement analysis.

Table 3-7 illustrates how both monetized and nonmonetized effects were presented to the task force in the final evaluation report.

**TABLE 3-7**
Summary of Findings for Two Representative Scenarios

| Planning Scenario | Components | Value Analysis Findings |
|---|---|---|
| Reduced Highway Expansion + Phased Commuter Rail + Tolled Express Lanes | • Reduced highway expansion plan<br>• Enhanced bus service<br>• Commuter rail service on existing freight alignments in Northeast & Southeast & 2 BRT services<br>• Tolled express lanes on added capacity on I-65 and I-69 | • Requires $300 million in locally funded investment beyond currently planned expenditures<br>• Generates a 6.0% return on investment or $3.4 billion of benefit in excess of costs<br>• Creates over 4,240 jobs and $23.2 billion in added business output |
| Reduced Highway Expansion + Phased Blended Rail + Tolled Express Lanes | • Reduced highway expansion plan<br>• Enhanced bus service<br>• Combination of all-day & commuter rail on existing freight facilities and in-street light rail<br>• Tolled express lanes on added capacity on I-65 and I-69 | • Requires $900 million in locally funded investment beyond currently planned expenditures<br>• Generates a 6.8% return on investment or $4.9 billion of benefit in excess of costs<br>• Creates over 4,870 jobs and $27.4 billion in added business output |

### *Technical Attribute #3:*
### Impacts on the nonusers of planning options and projects are estimated

Impacts on nonusers were estimated within three broad categories: regional macroeconomic effects; community livability benefits; and emission savings.

- **Regional macroeconomic effects**. The short-term and long-term effects of each planning option on the regional economy were estimated using an economic impact model. Short-term effects refer to job creation from construction spending and its multiplicative effects on the economy (for example, highway construction workers spending their income on locally produced haircuts).

Long-term effects result from improvements in the movement of goods and services by making the region a more attractive place to live and work and by creating lasting economic opportunities.

- **Community livability benefits**. Livability benefits were estimated as the extra or "premium" rate of residential and commercial property appreciation—above and beyond the general rate of appreciation. Premiums observed in comparable settings (regions and systems), and those reported in the economic literature were used to estimate the likely increase in property values in Central Indiana (a general estimation approach referred to as "Benefit Transfer"). These premiums arise from investors' and buyers' increased willingness-to-pay for a location. They reflect both the capitalized value of future transportation benefits (for example, reduced travel times) and additional livability benefits. These include the option value of transportation investments (for example, the value people derive from having the "option" of using an alternative mode of transportation even if they don't actually use it) and the amenities they may generate (for example, increased walkability or community cohesion).
- **Emissions savings**. Emissions savings were estimated as the difference between total emission costs under each planning scenario and the "base case." Vehicular emissions of carbon monoxide (CO), nitrogen oxide ($NO_X$), volatile organic compounds (VOC), particulate matter (PM) and carbon dioxide ($CO_2$) were estimated, and monetized using social cost estimates reported in the economic literature.

### *Technical Attribute #4:*
### The approach accounts for indirect effects such as changes in local employment and land use

Indirect effects such as changes in local employment were estimated as explained under Technical Attribute #3. Employment effects, however, cannot be treated as incremental welfare benefits (except under specific circumstances) and were not added to other measures of benefits in the estimation of net present value.

The land use effects of alternative scenarios were indirectly accounted for in the regional travel demand model used in the planning process. For example, higher population density was

assumed in the vicinity of the transit stations under planning options with investment in high capacity transit. Alternatively, scenarios focusing on highway expansion were associated with increased suburban sprawl, and modeled as such.

### *Technical Attribute #5:* Interactions ("synergies") among planning options are considered

The planning scenarios considered for evaluation represent a combination of different modes, initiatives, and projects. The interactions among these options were accounted for in the regional travel demand model, which considered "packages of options" as opposed to modeling each option individually over time.

The benefit-cost analysis itself was based, in large part, on output from the travel demand model. Output variables such as vehicle miles traveled, average vehicle speed, or transit ridership were used as input to the BCA. Scenarios with positive "synergies" among options (including those implemented at different locations across the regional transportation network) would—other things being equal—generate more economic value than those without.

This general approach to considering interactions, however, requires a significant effort when defining and packaging the options (as outlined under Principle #3) and substantial travel demand modeling work.

### *Technical Attribute #6:* The approach explicitly accounts for risk and uncertainty in forecasts and cost and benefit calculations

Risk analysis techniques were used in the evaluation of planning scenarios to account for uncertainty in the travel demand forecasts and other estimating assumptions. This includes assumptions reviewed during the stakeholder workshops (such as the value of time or the expected change in residential and commercial property values).

Statistical simulation techniques ("Monte Carlo simulations") were used to combine the uncertainty associated with all risk variables within the benefit-cost analysis model to arrive at a range of possible values (and full probability distribution) for

all performance indicators and summary metrics considered in the evaluation.

The use of risk analysis allowed the task force and other decision makers to account for both downside risk and upside potential in assessing candidate planning options. Summary outcomes are presented in Table 3-8, for illustration.

**TABLE 3-8**
Risk Analysis Outcomes, Net Present Value

| Planning Scenario | Net Present Value (Billions of 2009 Dollars) | | |
|---|---|---|---|
| | 90 percent chance of being exceeded | 50 percent chance of being exceeded | 10 percent chance of being exceeded |
| Reduced Highway Expansion + Phased Blended & Commuter Rail + Express Lanes | -$0.8 B | $4.8 B | $12.2 B |
| Reduced Highway Expansion + Blended Light & Commuter Rail + Express Lanes | -$2.3 B | $3.4 B | $10.5 B |
| Reduced Highway Expansion + Phased Commuter Rail + Express Lanes | -$1.2 B | $3.4 B | $8.8 B |
| Reduced Highway Expansion + Blended Light and Commuter Rail | -$2.5 B | $3.2 B | $10.3 B |
| Reduced Highway Expansion + Light Rail + Express Lanes | -$0.6 B | $2.8 B | $9.6 B |
| Reduced Highway Expansion + Light Rail | -$2.7 B | $2.6 B | $9.3 B |
| Reduced Highway Expansion + Commuter Rail + Express Lanes | -$2.1 B | $2.5 B | $8.2 B |
| Reduced Highway Expansion + All Freeway Pricing | -$1.8 B | $2.5 B | $7.5 B |
| Reduced Highway Expansion + Express Lanes | -$1.8 B | $2.4 B | $7.5 B |
| Reduced Highway Expansion + Commuter Rail | -$2.3 B | $2.3 B | $8.1 B |

As can be seen in the table, the top-ranking scenario (Reduced Highway Expansion + Phased Blended & Commuter Rail + Express Lanes) had a median net present value of $4.8 billion, and an associated confidence interval ranging from negative $0.8 billion to positive $12.2 billion. In other words, the risk analysis indicated that there was an 80-percent probability that the true net present value of the option would eventually be found between -$0.8 billion and $12.2 billion.

## Existing and Future Applications

As explained earlier, this case study is a one-time application of LCP to transportation planning in Central Indiana, commissioned by representatives from the private sector. It is not clear at this stage whether there will be other applications, but the Indianapolis Metropolitan Planning Organization (IMPO) expressed interest in implementing a similar approach for future planning efforts. No specific timeframe or level of effort has been determined for this next step to occur.

The four case studies provide many lessons for Oregon about the opportunities and challenges of applying a LCP methodology to transportation decisions. Main findings that span the four case studies are listed below. Tables 4-1 and 4-2 summarize how the four case studies, as a whole, address the principles and technical attributes of LCP.

## Main Findings

1. *LCP has helped agencies and stakeholders make more transparent and informed decisions.* Each of the four case study agencies see its application of LCP principles (regardless of what they were called) as a success, and evidence suggests that this is true. Each agency's LCP application provided a framework for better-informed decisions, helped tie transportation decisions to larger policies on livability and the environment, and directly addressed citizens' values. This was due, in part, to the way the processes were managed. And it was due, in part, to the new ways that agencies and researchers quantified and monetized impacts and benefits of interest to stakeholders. This includes the effects of alternatives on physical activity, public health, economic development, housing prices, congestion, safety, and other variables.

2. *Applications have evolved in response to each agency's unique mission, mandate, and goals.* Although it was different for each agency, all case studies had a discrete mandate that led to LCP development and implementation. For PSRC, it was a legislative mandate. For NATA, it was a policy direction following the election of the Labor party. For Central Indiana, it was frustration on the part of private industry over how processes had been structured in the past. VTrans2025 developed the multimodal coordination structure but in VTrans2035 expanded it to include more community involvement. LCP isn't developed for the sake of development; its inception comes from overarching agency policies and goals. These goals need to be identified first, before any tool development can occur.

3. *Stakeholders have helped improve the tools and the process.* LCP's stakeholders include individuals and organizations that tend to bring substantial expertise in economic analysis and policy. One key stakeholder in the

NATA process was Sir Rod Eddington, author of the Eddington Transport Study. Eddington's study contributed greatly towards the development of NATA *Refresh*. This in turn moved the UK's guidance from traditional cost-benefit to a much more robust process that weaves in many of the government's current environmental policies. Stakeholders of the Central Indiana case study drove the process itself, with the recommendations presented to the MPO. Stakeholders in LCP development may not be the same set of individuals that are typically engaged in transportation planning and project development efforts, but their input and expertise is critical.

4. *Many LCP applications begin with a benefit-cost framework.* LCP as a term is not widely used in transportation. In fact, outside Washington and PSRC, it is not used in practice and PSRC has actually shifted over to BCA terminology to describe their application. Although Chapter 2 describes many methods for addressing LCP principles and attributes, the most common (as exampled in three of the four case studies) framework is BCA.

5. *LCP has been applied at both project and system levels.* PSRC's tool calculates the net consumer benefit associated with each of a variety of regional scenarios (for example, highway capacity/no toll, highway capacity/toll, transit/toll, and so forth). Similarly, VTrans 2035 evaluated packages of improvements centered around corridors. NATA, on the other hand, was developed to evaluate individual projects. Central Indiana has the capability to be used at both the network and project scale. Many agencies interviewed expressed a desire to broaden the use of its tool and—for different reasons—the difficulty of doing so.

6. *Applications have evolved and improved over time.* Most of the case study locations were using their application in its second iteration. PSRC started with Destination 2030 and has now adopted Transportation 2040. The UK has now released NATA *Refresh*. VDOT has now adopted VTrans2035. In each case, many lessons learned on the first attempt have been incorporated in the second iteration. Further, all agencies have a work program that will allow them to continue to work on measuring many intangibles.

## Common Principles

Table 4-1 summarizes how staff and stakeholders in each of the four case study locations address the principles of LCP.

**TABLE 4-1**
Summary of How Case Studies Address LCP Principles

| LCP Principles | PSRC | NATA | VTrans 2035 | Indianapolis |
|---|---|---|---|---|
| Multiple goals | ✓ | ✓ | ✓ | ✓ |
| Oregon-specific policy goals | Partially | Partially | Partially | Partially |
| Demand-management and other planning options | ✓ | ✓ | ✓ | ✓ |
| Engagement of communities and decision makers | ✓ | Partially | ✓ | ✓ |
| Useful basis for choice | ✓ | ✓ | ✓ | ✓ |
| Project specific or multiproject | Multiproject | Project | Multiproject | Multiproject |
| Has been used in decision support | ✓ | ✓ | ✓ | ✓ |

Each of the four case studies uses LCP to evaluate the extent to which investments, or sets of investments, achieve multiple goals of mobility, equity, safety, environment, and others. LCP provides a framework for understanding tradeoffs among these sometimes divergent goals.

Similarly, even though none of the case studies were located in Oregon, many of Oregon's goals (as stated in the most recent Oregon Transportation Plan) are similar or identical to agency goals in the case study locations. All agencies have goals for economic development, safety, mobility, fiscal responsibility, livability, and environmental responsibility. Thus, there are several indications of how Oregon's goals could be addressed through LCP analysis techniques.

All case studies consider demand management, among other strategies, as part of their analyses. In some cases, the demand management and system management options are included in a base case. In other cases, demand management, including road pricing, is one of the alternatives considered.

To varying degrees, each case study engages the community and decision makers in the development and application of LCP. NATA *Refresh* provides the most robust example of engaging the research community. NATA *Refresh* also provides

an example of how input can shape the process. The Indiana case study was actually *led* by stakeholders, and presented to the agency. The PSRC and VTrans cases engaged both internal and external stakeholders in the development of investment alternatives.

Two of the case studies—PSRC and VTrans2035—use LCP for network choices (packages of improvements); whereas the other two—Indiana and NATA—focus on project-specific choices. Indiana is an example application that is used for both project and network-based choices. Many agency staff who were interviewed stated that expanding the use of their LCP tool (from network to project, from project to network) was a primary focus for future development.

Finally, all case studies found that LCP provides a useful framework for balancing the tradeoffs of various project scenarios. It helps inform the decisionmaking process, increase transparency, and reduces the level of "unknowns."

## Common Attributes

Table 4-2 summarizes how the four case studies address LCP technical attributes.

**TABLE 4-2**
Summary of how Case Studies Address LCP Technical Attributes

| LCP Attributes | PSRC | NATA | VTrans 2035 | Indianapolis |
|---|---|---|---|---|
| Facilitates comparison of options | ✓ | ✓ | ✓ | ✓ |
| Uses quantitative and qualitative evidence | Both | Both | Predominantly Qualitative | Predominantly Quantitative |
| Considers impacts on nonusers | ✓ | ✓ | ✓ | ✓ |
| Accounts for indirect effects | | ✓ | | ✓ |
| Considers interactions and synergies | | | ✓ | ✓ |
| Accounts for risk and uncertainty | ✓ | ✓ | | ✓ |

In each process, staff and stakeholders use LCP to facilitate a transparent comparison among options. All applications use both qualitative and quantitative evidence, though the Indiana analysis relies principally on quantitative data and the Virginia example, on qualitative data.

Most case studies consider impacts on both users and nonusers, and several also consider the indirect effects of a transportation investment on the built environment.

All case studies account for interactions among various modal investments and the synergies among projects within network package investments. All case studies also account somehow for risk and uncertainty, though the specific application among the different case studies varies.

The information presented in this discussion paper helps frame, for Oregon, both how LCP *could* be applied to transportation, and how it *has* been applied to transportation. There are many challenges and complexities to developing a tool that will prove useful to the state. Further, several key decisions need to be addressed by the DOT and its stakeholders before any tool can be developed.

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# Appendixes

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# Appendix A
# Glossary

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APPENDIX A

# Glossary

**Accessibility**: the ability to reach opportunities (i.e., desired activities, services or destinations).

**Agglomeration Benefits**: increase in productivity resulting from the spatial concentration of firms and workers.

**Benefit/Cost Ratio**: a measure of worth or value for money used in benefit-cost analysis; the present value of total benefits divided by the present value of total costs

**Benefit-Cost Analysis (BCA)**: a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a proposal (a plan, program, project, or policy) as feasible; including items for which the market does not provide a satisfactory measure of economic value. BCA helps determine whether and to what extent a proposal is worthwhile from a "social" perspective, as opposed to a private, financial perspective.

**Community Impact Evaluation:** see Planning Balance Sheet.

**Congestion Management**: strategies aimed specifically at reducing congestion, or mitigating the social costs of congestion.

**Consumer Surplus**: the difference between the total amount consumers would be willing to pay for an item (a good or service) and the amount they actually pay for it. In transportation, the change in consumer surplus is often used as a measure of user benefits where the item transacted is a trip and the "price" of the trip is the generalized cost of travel.

**Cost Effectiveness Analysis**: an analysis that compares the effectiveness of--or outcomes associated with--using a given amount of resources, in different situations.

**Cost Minimization**: an analysis that compares the costs of alternative ways of producing the same or similar outputs, with a view to select the cost minimizing option.

**Discounting**: a method used to convert future costs or benefits into a common year (present value) for comparison.

**Discount Rate**: the annual percentage change in the present value of a future dollar, or other unit of account. The discount rate used in public sector evaluations is either the social time preference rate (the value society attaches to present as opposed to future consumption) or the opportunity cost of capital.

**Economic Impact Analysis (EIA)**: an analysis of the total effects of a plan or project on the level of economic activity in a region. EIA focuses on macroeconomic indicators such as output, income, or employment; and forecasts the influence of the plan or project on these indicators.

**Externality**: a cost or benefit incurred by a party that did not participate in the action causing the cost or benefit. Environmental pollution is an example of negative externality,

as its costs are rarely borne completely by the polluter. The benefits of immunization to those who are not immunized are an example of positive externality.

**Generalized Cost of Travel**: the total cost incurred by a traveler when making a trip, including out-of-pocket costs (for example, vehicle operating costs, and tolls) and the monetized value of his/her time.

**Goal Achievement**: an evaluation method focusing on the extent to which a plan or project is expected to meet objectives that have been set in advance. Variations of goal achievement include: "bending on" (defining an ideal urban or regional form, and assessing whether proposed options approximate the form), the "goals achievement matrix" (consideration of multiple objectives combined with weights), and "objective fulfillment analysis" (scoring and ranking of options, and use of probabilities of implementation in weighting).

**Integrated Resource Planning (IRP)**: a general approach to planning focusing on the integration of supply-side and demand-side options, and having many of the attributes of least cost planning. Although differences between the two concepts were initially emphasized, they are often used interchangeably now.

**Internal Rate of Return**: the discount rate that would give a project a net present value of zero.

**Life-Cycle Cost Analysis (LCCA)**: an analysis of the costs of a project or plan over its entire life span, from "cradle to grave." including preliminary engineering and design; construction; maintenance and repair; operations; and disposal/demolition. LCCA in transportation may be expanded to include user costs (including travel time, vehicle operating cost, and other costs).

**Mobility**: the ability to move from one location to another. Mobility refers to the physical movement of goods and people.

**Mode**: a particular form or means of travel (for example, walking, bicycling, driving alone, carpooling, bus, train, ferry, airplane).

**Monetization**: the process through which an impact (a cost or benefit) is expressed in terms of money or currency value.

**Multi-Criteria Analysis (MCA)**: an evaluation methodology that considers many objectives by the attribution of a weight to each measurable objective. In contrast to benefit-cost analysis that focuses on a unique criterion (the maximization of social welfare), MCA is a tool for dealing with a set of different objectives that cannot be aggregated through monetary valuation, as in standard BCA.

**Multimodal Tradeoff Analysis**: a process through which a transportation agency evaluates choices between various modes, in particular with respect to resource allocation (how much resource should be allocated to Mode A as opposed to Mode B?)

**Multimodal**: the attribute of a plan, project, or activity that involves or affect more than one mode of transportation.

**Multiple Account Evaluation (MAE)**: an evaluation framework where the effects of a project or plan are divided into "accounts" to show different perspectives (for example, economic development account, environmental account, safety account). MAE may include qualitative and quantitative evaluation criteria. The relative importance of each criteria, and account, may be determined by decision makers.

**Net Present Value**: the present value of total benefits minus the present value of total costs.

**Performance Indicator**: a measure designed to assess the performance of a system or an organization; its progress toward - or movement away from - a goal or set of goals.

**Planning Balance Sheet (Also Known as Community Impact Evaluation)**: a framework for the evaluation of planning options from the point of view of various groups within a community. Options are compared using costs and benefits expressed in monetary terms, as well as those measured in other units, and those that can only be assessed qualitatively. The planning balance sheet was developed in the United Kingdom in the 1960s and was renamed "community impact evaluation" in the 1990s.

**Present Value:** the value of future costs or benefits expressed in present terms by means of discounting.

**Producer Surplus**: the difference between what producers are willing and able to supply a good or service for, and the price they actually receive. The value a producer receives over and above his/her actual costs of production.

**Regeneration**: a set of interventions or programs designed to improve the quality of life in an area through economic, social, or environmental means.

**Risk Analysis**: a process through which the odds-- or likelihood--of alternative outcomes can be assessed. Risk analysis typically involves the use of simulation methods that account for uncertainty in all key inputs and their correlations, simultaneously.

**Sensitivity Analysis**: a technique used to determine how changes in the value of an explanatory variable impacts the value of an output variable; how "sensitive" a model is to changes in estimating assumptions. It is generally carried out by varying one variable at a time.

**Social Welfare**: the overall welfare of society, typically defined as the summation of the welfare (the well-being or quality of life) of all individuals in society. *Changes* in social welfare--as opposed to measures of *total* welfare--are typically reported in benefit-cost analyses.

**Social Return on Investment (SROI)**: a quantitative measurement of how effectively an organization uses its resources to generate value for society--including social, environmental, and economic value. SROI was initially developed by a San Francisco-based philanthropic fund (REDF, formerly the Roberts Enterprise Development Fund) investing in social enterprises. An SROI metric is the numeric result of an SROI analysis.

**Sustainability**: the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is also defined more generally as the ability to endure.

**Sustainable Return on Investment (SROI)**: an evaluation process that accounts for a project's triple-bottom line--including social, environmental, and economic impacts. SROI builds on benefit-cost analysis and financial analysis, supplemented by stakeholder elicitation techniques and risk analysis. Sustainable ROI has many of the attributes of social ROI, but has a different focus and has been used in different applications (infrastructure investments for the former; social enterprises for the latter).

**Transportation Demand Management (TDM)**: strategies aimed at a more efficient use of existing transportation resources and generally focused on changing or reducing travel demand (particularly during peak hours). TDM covers a wide range of initiatives, including: congestion pricing; alternative work schedules; telecommuting or distance learning; parking management; carpooling or vanpooling; and transit improvements.

**Transportation System Management (TSM)**: strategies aimed at improving the overall performance of the transportation network without resorting to large-scale capital improvements. Examples of TSM actions include: innovative roadway designs; improved signalization; incident response plans; or electronic freight management systems.

**Vehicle Miles Traveled or Vehicle Miles of Travel (VMT)**: total miles traveled by all vehicles during a specified period of time. One VMT is one vehicle traveling the distance of 1 mile.

**Wider Economic Benefits (or Wider Impacts)**: the indirect impacts a transportation project or plan can have on transportation-using markets that are not perfectly competitive (an assumption of conventional benefit-cost analysis is that all markets are perfectly competitive). These impacts are generally omitted in benefit-cost analysis, although recent evidence from the United Kingdom suggests that they could be substantial. Agglomeration benefits are an example of wider impacts.

**Willingness-to-pay**: the amount consumers are prepared to pay for a final good or service. If a consumer's willingness-to-pay for a good exceeds its price, the consumer enjoys a "rent," the consumer's surplus.

# Appendix B
# Annotated Bibliography

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**APPENDIX B**

# Annotated Bibliography

This appendix provides an annotated bibliography of research and applications of least cost planning (LCP) to transportation undertaken since the mid 1990s. It is organized into two sections: 1) general research findings, and 2) additional notes on candidate case studies.

In the first section, each research item is summarized in a tabular format with the following information: title, author(s), date of publication, number of pages, relevance, and a link to its location online. Each research item also contains an abstract, either taken directly from the publication or developed by the research team. Tables are grouped within three broad categories: i) definition, theory, and general guidance; ii) conceptions and applications in the U.S.; and iii) conceptions and applications abroad. Many of the research items we have reviewed provide both theory—or general guidance—and case study applications. To simplify things, the research team has restricted "theory" citations to documents that were not authored by agencies about their own applications; and have included in "theory" those items predominantly about theory but including, possibly, a third-party case study review. Within each category, research items are sorted in decreasing order of relevance (in other words, the items deemed most relevant to the study are listed first).

In the second section, the team provides a summary of information on potential case study applications identified during the initial desktop research. This research was conducted prior to the case studies task and included several applications that were not ultimately selected for further analysis. These include: VDOT's Multimodal Investment Network; CALTRANS' Sustainable Communities Strategy; New Zealand Transport Agency's Accessibility Planning; Auckland Regional Transport Authority's Integrated Transport Assessment; the UK Department for Transport's New Approach to Appraisal; the European Commission's Strategic Environmental Assessment; Washington DOT's Multimodal Investment Choice Analysis; and Puget Sound Regional Council's LCP Analysis. Technical Memorandum #2: Summary of Case Studies expands on the findings of three of these efforts (Puget Sound, United Kingdom, Virginia) as well as a fourth case study, the Central Indiana Transportation Plan.

Finally, it is important to note that through this research, the team found that often transportation-related LCP principles were applied, but not explicitly referred to, as "least cost planning." Principles were also referred to as "integrated resource planning," "multimodal investment choice analysis," "cost-benefit analysis," "multimodal tradeoff analysis," among others.

The team has found that each of the research items summarized in this document demonstrates some attributes and/or principles of LCP, which are defined as follows:

Principles of LCP:

- The evaluation framework rolls up multiple goals;

- A broad range of possible multimodal capacity, demand management, land use, maintenance, and other planning options can be considered;
- Members of the community and decision makers are engaged in the planning and decisionmaking process;
- The approach facilitates the adoption of a meaningful, relevant, and operationally useful basis for choice; and
- The methodology can be applied at the project-specific level, and the collective (multiproject) level.

Technical Attributes of LCP:

- Costs and benefits are measured in terms that facilitate the comparison of planning options (such as monetary-equivalent units);
- The approach makes use of quantitative and qualitative evidence;
- Impacts on users (e.g., those regularly using the system being explored for improvement) vs. nonusers (for example, general public) are estimated;
- Indirect effects, such as changes in local employment and land use, are accounted for;
- Interactions ("synergies") among planning options are considered; and
- The approach explicitly accounts for risk and uncertainty in forecasts and cost and benefits calculations.

# 1—General Research Findings

## Definition, Theory, and General Guidance

| Title | Economic Analysis Primer |
|---|---|
| Authors | Federal Highway Administration, Office of Asset Management |
| Date | August 2003 |
| Pages | 36 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★★★ |
| Abstract | This primer provides a foundation for understanding the role of economic analysis in highway decision making. It is oriented toward state and local officials who have responsibility for assuring that limited resources get targeted for their best uses and who must account publicly for their decisions. It presents economic analysis as an integral component of a comprehensive infrastructure management methodology that takes a long-term view of infrastructure performance and cost. The primer is organized into six chapters, and covers the following topics: Economic Fundamentals; Life-Cycle Cost Analysis; Cost-Benefit Analysis; Forecasting Traffic for Benefit Calculations; Risk Analysis; and Economic Impact Analysis. Details on specific technical issues are discussed in text boxes throughout the report. These include: formulas for adjusting for inflation; formula for discounting; treatment of revenues, tolls, taxes, and other transfers in cost-benefit analysis; and use and interpretation of the benefit/cost ratio. |
| Online | http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer.pdf |

| Title | Least Cost Planning: A Tool for Metropolitan Transportation Decision Making |
|---|---|
| Authors | Dick Nelson and Don Shakow |
| Date | May 1996 |
| Category | Definition, theory and general guidance |
| Relevance | ★★★★ |
| Abstract | This paper describes a “new” approach to transportation investment planning and a prototype computer model. The model incorporates the principles of LCP and full cost accounting; and was developed to assist metropolitan transportation planners and decision makers in meeting federal and state planning requirements. It attempts to promote an efficient search for investment and policy options that enhance regional benefits, while reducing social costs.<br>The LCP model was designed to identify a package of transportation options for a study area satisfying the following criteria:<br>• The package meets the access needs of the area for a variety of trip |

| Title | Least Cost Planning: A Tool for Metropolitan Transportation Decision Making |
|---|---|
| | purposes and special populations.<br>• The package results in a maximum net-reduction in social cost as compared to a no-action base case;<br>• Costs are inclusive of private costs, government subsidies, environmental and pecuniary externalities, congestion, and other travel time costs.<br>• The range of options surveyed is complete, inclusive of Transportation System Management (TSM) and Travel Demand Management (TDM) options, and mindful of various ride sharing, transit, low-powered, and nonmotorized modes.<br>• The optimal package accounts for synergies among options and for the time path over which the options are implemented.<br>An application of the model for the Puget Sound metropolitan region was carried out by comparing a limited number of options. These include a set of study options associated with a proposed light rail system; two commuter rail options; an option featuring the construction of an ambitious bicycle and pedestrian network; a highway construction option; and a series of options emphasizing public and private incentives directed toward reduced single occupancy vehicle use. The analysis suggests that a well-coordinated set of demand management measures in conjunction with modest investment in infrastructure may be cost-effective relative to major construction projects. |
| Online | http://www.globaltelematics.com/lcp/nel4.htm |

| Title | Least Cost Planning: Principles, Applications and Issues |
|---|---|
| Authors | U.S. Department of Transportation, Federal Highway Administration, prepared by EcoNorthwest, Parsons Brinckerhoff and COMSIS Corporation |
| Date | July 1995 |
| Pages | 128 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★★★ |
| Abstract | In this report for FHWA, LCP is presented as both a planning process and a set of specific analytical techniques. LCP attempts to meet a given set of transportation objectives with a combination of improvements, policies, and programs that is less expensive than any other combination. Among the principles of LCP are:<br>• Application of benefit-cost techniques to the evaluation of alternative transportation systems and projects;<br>• Consideration of policies and investments to reduce demand for transportation facilities on equal footing with those that increase the supply of those facilities;<br>• Evaluation of the uncertainties in forecasts of future travel demand and the performance of different alternatives; |

| Title | Least Cost Planning: Principles, Applications and Issues |
|---|---|
| | • Involvement of the public in the development of alternatives and their evaluation; and<br>• Coordination among different agencies and jurisdictions of a system-wide planning effort that regularly updates plans to reflect new information about those measures that are most cost-effective.<br>The report is organized into a number of chapters and appendices, including: The Case for Least Cost Planning; Evaluating the Benefits and Costs of Transportation; The Least Cost Planning Process; and Steps Towards Implementing Least Cost Planning. It identifies the gap between "theory and practice" as the primary obstacle for the use of LCP for project evaluation; and concludes: "it is our belief that until the concepts of project evaluation (described in this report) are debated, modified, and moved into the mainstream, it is idle to work out the details of the measurements for MPOs to apply in a cookbook fashion." |
| Online | http://www.oregon.gov/ODOT/TD/TP/docs/LCP/LCPpaper.pdf |

| Title | Evaluation Methodology of Urban and Regional Plans: A Review |
|---|---|
| Authors | Nathaniel Lichfield |
| Date | April 1970 |
| Pages | 15 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★★★ |
| Abstract | This article makes a comparative review of about 20 plan evaluation methodologies that have been used in practice or advocated in the literature. These include: enumeration of advantages and disadvantages; financial appraisal; goal achievement; cost minimization; cost effectiveness analysis; cost-benefit analysis; linear programming; or the planning balance. Each methodology is described briefly and assessed against a set of ten criteria to which comprehensive evaluation methodologies should conform. Examples of applications with references are also provided, where available. The article concludes in favor of the Planning Balance Sheet, a form of cost-benefit analysis applied to urban and regional planning, as having the greatest potential. The Planning Balance Sheet was subsequently renamed "Community Impact Evaluation." |
| Online | http://www.informaworld.com/smpp/title~content=t713393953<br>(Subscription Required) |

| Title | Multimodal Tradeoff Analysis Research Helps Clarify Funding Allocation and Priority Scenarios |
|---|---|
| Authors | Virginia Department of Transportation<br>Prepared by Ken Winter |
| Date | May 2007 |
| Pages | 33 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★★ |
| Abstract | This document, itself, is an annotated bibliography and includes a selected list of articles and reports on the topic of Multimodal Tradeoff Analysis. Of special interest are: Multimodal Investment Choice Analysis for Washington State Transportation; The Sensitivity of Optimal Transport Strategies to Specification of Objectives; Trade-off/Positional Analysis as an Alternative to Cost-Benefit Analysis in Socio-Technical Decisions; Total Cost Analysis: An Alternative to Benefit-Cost Analysis in Evaluating Transportation Alternatives; or Accommodating Multiple Alternatives in Transportation Planning.<br><br>Report citation (see part 2 of this appendix): *Multimodal Investment Choice Analysis,* Washington State Department of Transportation, June 2002. |
| Online | http://vtrc.virginiadot.org/rsb/RSB7.pdf |

| Title | Multimodal Transportation:<br>Development of a Performance-Based Planning Process |
|---|---|
| Authors | National Cooperative Highway Research Program, Transportation Research Board, National Research Council; prepared by Cambridge Systematics |
| Date | December 1999 |
| Pages | 48 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★★ |
| Abstract | This report is intended to provide transportation organizations, planning practitioners, and transportation decision makers with practical tools and guidance for considering system performance in the multimodal transportation planning and decisionmaking process. It is also expected to support transportation investment decisions tailored to the specific conditions and performance needs of major transportation systems. Presented as a guidebook, it brings together lessons learned from different regions of the country and establishes a rationale for performance-based transportation planning and provides guidance for a wide range of applications having different scopes and levels of complexity. The guidebook provides a structured approach to monitoring, evaluating, and considering |

| Title | Multimodal Transportation: Development of a Performance-Based Planning Process |
|---|---|
| | transportation system performance in various components of the planning process. It also includes a "Performance Measures Library" that catalogs measures currently being applied throughout the country. Although the guidebook addresses many of the fundamental activities included in effective performance-based planning studies, the emphasis is not solely on the process; but on how to organize and employ systematic, effective performance measures to support planning analyses and decisions. The report also emphasizes the importance of integrating planning and project development so that decision making is, in effect, seamless and objective. |
| Online | http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w26-a.pdf<br>http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=901 |

| Title | Demand Management as an Element of Transportation Policy: Using Carrots and Sticks to Influence Travel Behavior |
|---|---|
| Authors | Michael D. Meyer |
| Date | 1999 |
| Pages | 25 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★ |
| Abstract | This paper describes the characteristics of Transportation Demand Management (TDM). The origin of TDM as it has evolved in the U.S. is related to federal policy initiatives that first focused on improving the efficiency of the urban transportation system through operational improvements, and then incorporated concerns such as air quality and energy conservation into the transportation planning process. The paper then examines the effectiveness of TDM actions, and concludes that those actions most likely to increase the “price” of travel for single occupant vehicle use will be most effective. The paper identifies several strategies for improving the effectiveness of TDM actions in the context of regional transportation planning, including: incorporating TDM as part of the solutions for regional transportation planning, linking TDM to land use decisions, making the costs of travel more apparent to the user, and making TDM implementation more palatable to the general public. |
| Online | www.ScienceDirect.com (Subscription Required) |

| Title | Public Involvement Techniques for Transportation Decision Making |
|---|---|
| Authors | Federal Highway Administration; prepared by Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas |
| Date | September 1996 |
| Pages | 68 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★ |
| Abstract | This report provides transportation agencies with a variety of tools and techniques to involve members of the general public in the development or review of specific plans, programs, or projects. The report is organized into four chapters: Informing People through Organization and Outreach; Involving People Face-to-Face through Meetings; Getting Feedback from Participants; and Using Special Techniques to Enhance Participation. Each chapter is broken down into several subsections containing groups of public involvement techniques. The basic organizing principle of each of the techniques is a series of questions, such as "Why is it useful?" "How much does it cost?" and "What are the drawbacks?" To assist practitioners in coordinating a full public involvement program, each technique is cross-referenced to other techniques, where appropriate. |
| Online | http://www.fhwa.dot.gov/reports/pittd/cover.htm |

| Title | Transportation DSM: Building on Electric Utility Experience |
|---|---|
| Authors | Edward L. Hillsman |
| Date | 1995 |
| Pages | 13 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★★ |
| Abstract | This article describes the benefits resulting from considering Demand Side Management (DSM) within a framework of integrated resource planning. While DSM was first developed in the electric utility industry, strong parallels exist between transportation and electric utilities. The initial force behind DSM in the electric utility industry arose from difficulties in expanding capacity. Similarly in transportation, increasing road capacity to meet demand can be very high, especially in built-up areas. On the other hand, important differences exist between the two sectors, including the following:<br>• Electricity users in developed countries where DSM was developed rarely experience differences in service quality between peak and off-peak periods. Transportation users, by contrast, are likely to experience congestion, crowding on public transportation, and other variations in the quality of service.<br>• Energy cost tends to be a much higher proportion of the total cost of |

| Title | Transportation DSM: Building on Electric Utility Experience |
|---|---|
| | delivering electricity services.<br>Given existing regulations in the electric utility industry, the general objective in that sector is "straightforward:" select the investments that allow delivery of service at least cost. By contrast, decision making in transportation is more fragmented, and many services are not priced in monetary terms. The paper concludes that differences between the two sectors are likely to make it difficult to transfer planning options and concepts from one sector to the other. A more detailed examination, however, may suggest alternative approaches to implementation, which may overcome some of these difficulties. |
| Online | www.ScienceDirect.com (Subscription Required) |

| Title | Decision Making, Intermodal Transportation, and Sustainable Mobility: Towards a New Paradigm |
|---|---|
| Authors | Joseph S. Szyliowicz |
| Date | 2003 |
| Pages | 13 pages |
| Category | Definition, theory and general guidance |
| Relevance | ★ |
| Abstract | This article claims that the transportation problem facing the United States and many other countries cannot be solved effectively without a new approach to transportation planning. First of all, policymakers and the general public must recognize the shortcomings of existing planning practices. Secondly, more sophisticated modeling tools are needed to understand and predict the impacts of transportation decisions, and be of greater use to practitioners and decision makers. According to Szyliowicz, the new transportation system must be based on the principle of "intermodalism" (efficient connections and coordination between modes, including between government agencies and the private sector at all levels). It must not only be economically efficient and financially sound, but also environmentally benign, safe and secure, and must contribute to social development. |
| Online | http://www.ingentaconnect.com/content/bpl/issj/2003/00000055/00000176/art00003 |

## Conceptions and Applications in the United States

| Title | Least Cost Planning Guidance |
|---|---|
| Authors | Washington State Department of Transportation |
| Date | October 2009 |
| Pages | 4 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★★ |
| Abstract | This brief report presents guidance by the Washington State Department of Transportation (WSDOT) on how to adopt LCP. In 1994, the Washington State Legislature passed a billed requiring regional transportation planning organizations to develop regional transportation plans based on a LCP methodology. In this paper, WSDOT argues that LCP becomes a form of benefit-cost analysis when applied to transportation. For guidance on benefit-cost analysis, the department refers to a Federal Highway Administration primer on economic analysis, available online, and summarized earlier in this annotated bibliography. |
| Online | http://www.wsdot.wa.gov/NR/rdonlyres/FDBC2704-7998-49D9-9F70-B16F5D1A0B2E/0/LeastCostPlanningexampledefinitionsfordiscussion.pdf |

| Title | Multimodal Investment Choice Analysis |
|---|---|
| Authors | Washington State Department of Transportation; prepared by Rhonda Young, Jennifer Barnes, G. Scott Rutherford, Washington State Transportation Center |
| Date | June 2002 |
| Pages | 316 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★★ |
| Abstract | The Multimodal Investment Choice Analysis (MICA) is a computer-based evaluation tool designed to assist the Washington State Department of Transportation, the Washington State Transportation Commission, and the Washington state legislature in making state transportation funding decisions. The function of MICA is to summarize the multimodal budgetary tradeoffs that will result from varying funding allocation and priority scenarios. MICA's methodology is based on benefit-cost and goal achievement analysis. The purpose of this two-volume report is to document the methodology underlying the MICA program, and provide general findings from the research effort to date. This document is also designed to serve as a user's manual for operating the tool. |
| Online | http://www.wsdot.wa.gov/Research/Reports/500/547.1.htm |

| Title | Least Cost Planning: An Analysis of Metropolitan Transportation Plan Alternatives |
|---|---|
| Authors | Puget Sound Regional Council |
| Date | October 2000 |
| Pages | 70 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★★ |
| Abstract | This document describes the application of LCP to the system-level transportation alternatives contained in the Metropolitan Transportation Plan (MTP) Alternatives Analysis and Draft Environmental Impact Statement (DEIS) released August 31, 2000.<br><br>In developing the planning alternatives for the MTP Alternatives Analysis and DEIS, a broad range of investment and management options were narrowed down to a few using demand modeling analysis and a review of policy compatibility. Three MTP alternatives were developed to stimulate discussion of wide-ranging transportation choices and options for funding them: Updated 1995 MTP; Current Law Revenues; and MTP "Plus" (which included new general purpose and high-occupancy vehicle, or high occupancy vehicle (HOV) lanes, Intelligent Transportation Systems and Smart Travel programs, and transit system improvements).<br><br>The methods of LCP were used to evaluate the cost effectiveness of the MTP alternatives in terms of total cost per new trip. Based on this application, the PSRC concluded that:<br>• LCP tells us something about the cost effectiveness of alternative ways of serving a static number of trips, but does not fully compare the marginal cost and marginal benefit of the different transportation system alternatives.<br>• Least cost analysis of system level transportation alternatives can provide significant information relevant to the decision process.<br>• Least cost principles can guide the development of the system elements of a preferred metropolitan transportation plan alternative.<br>• System-level least cost analysis of transportation planning alternatives is not a substitute for corridor-, project-, or program-level benefit-cost analysis.<br><br>The Puget Sound Regional Council was selected as a case study candidate for this study.<br><br>Report citations (see part 2 of this appendix): *Least Cost Planning Guidance,* Washington Department of Transportation, October 2009, and *Least-Cost Planning: An Analysis of Metropolitan Transportation Plan Alternatives,* Puget Sound Regional Council, October 2000. |

| Title | Least Cost Planning: An Analysis of Metropolitan Transportation Plan Alternatives |
|---|---|
| Online | http://www.psrc.org/assets/3141/mtp_deis_vol2leastcost.pdf |

| Title | Least Cost Transportation Planning in ODOT |
|---|---|
| Authors | Oregon Department of Transportation, prepared by Center for Urban Studies, Portland State University and Oak Ridge National Laboratory |
| Date | May 1996 (Phase 2 Final Report)<br>March 1995 (Feasibility Report) |
| Pages | 64 pages, plus appendices (Phase 2 Final Report)<br>64 pages, plus appendices (Feasibility Report) |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★★ |
| Abstract | This two-volume report examines the applicability of LCP principles to transportation planning in Oregon. Volume 1 (Feasibility Report) provides an overview of the literature on LCP and Integrated Resource Planning; discusses the origins of LCP in the electric utility industry; and sets out the economic context for LCP (including the relation between cost effectiveness and cost-benefit analysis). Volume 1 also includes summaries of interviews with the utility industry and the transportation sector. The authors identify two important issues to be addressed in attempting to implement LCP: i) the identification of planning objectives; and ii) the definition of a procedure by which all planning options can be considered. Volume 2 (Phase 2 Final Report) documents the planning process used in a specific project and describes the changes that would be required to have the process conform to LCP. The report concludes that transportation planning could be changed to incorporate LCP principles, but that there is not a clear-cut set of changes that will accomplish this. It further argues that LCP should be used differently in the three distinct parts of the planning process (state, corridor and MPO, and project levels). |
| Online | http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/LeastCostTransPhase2.pdf |

| Title | Integrated Transportation Planning: A Primer for Policy Makers |
|---|---|
| Authors | Puget Sound Regional Council |
| Date | June 1995 |
| Pages | 16 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★★ |

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|---|---|
| Abstract | This report describes how integrated transportation planning (ITP), or least cost planning, can be applied to decision making undertaken by organizations such as the PSRC, state agencies, or local jurisdictions. The report reflects the current thinking of the Council about what integrated transportation planning is, and how it can improve decision making. PSCR defines ITP as a set of analytic methods for evaluating alternatives, and a planning process for selecting them. Five key principles are identified:<br>• Considering a full range of transportation alternatives;<br>• Using cost-effectiveness as a key criterion for selecting transportation investments and policies;<br>• Considering all significant social costs in the evaluation of alternatives;<br>• Engaging the public in the selection of a comprehensive transportation strategy; and<br>• Monitoring and adjusting the strategy based on feedback and re-evaluation.<br>The report also identifies a number of "serious challenges" to the application of ITP/LCP, including:<br>• The analytical techniques and planning processes are not fully developed, in particular for system-level analyses;<br>• Some may object to an over-reliance on the cost-effectiveness criterion; and<br>• ITP requires greater coordination among state, regional and local jurisdictions.<br>The Puget Sound Regional Council was selected as a case study candidate for this study. |
| Online | http://www.oregon.gov/ODOT/TD/TP/docs/LCP/TPprimer.pdf |

| Title | Sustainable Communities Strategy 2010 Working Draft |
|---|---|
| Authors | California Department of Transportation |
| Date | November 2009 |
| Pages | 222 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★ |
| Abstract | This report identifies the specific requirements of a Sustainable Communities Strategy (SCS) and defines additional items that could be included in an SCS. It is relevant to LCP in that the California DOT will be looking at the SCS as a way to better quantify benefits from reducing greenhouse gas emissions, and as a strategy for reducing the emissions themselves.<br><br>An SCS includes: (1) a land use component that explains how the region will be able to house its entire population over the next 8 years and the next 20 years; (2) a discussion of resources and farmland areas to be protected; (3) a transportation network; and (4) a demonstration of how the expected development pattern and transportation network can "work together" to |

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| | reduce greenhouse gas emissions in order to meet the targets set forth by California's Air Resources Board.<br><br>Report citation (see part 2 of this appendix): *2010 Working Draft California Regional Transportation Plan Guidelines,* California Department of Transportation, November 2009. |
| Online | http://www.catc.ca.gov/programs/rtp/Archive/DraftRTP_Guidelines_ver_1_7_112309.pdf |

| Title | Multimodal Tradeoffs Discussion Paper |
|---|---|
| Authors | Oregon Department of Transportation; prepared by Cambridge Systematics |
| Date | August 2007 |
| Pages | 23 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★ |
| Abstract | The purpose of this paper is to generate and support discussion within the Oregon Department of Transportation and the Oregon Transportation Commission on the subject of "Multimodal Tradeoff Analysis" (MTA). It identifies the questions addressed by MTA; describes the benefits of multimodal tradeoffs; summarizes the state of the practice; and discusses current and potential future applicability in Oregon.<br><br>The primary question to be addressed by MTA is defined as follows: "*How can the State invest transportation dollars to obtain the best combination of immediate and longer-term benefits to users, regardless of modal system?*" Additional, secondary questions are related to modal diversion (will the intended diversion take place?); the extent and distribution of benefits; funding sources (private vs. public); and the use of mode-neutral criteria in decision making.<br><br>The potential benefits of multimodal tradeoffs are numerous. They include: expanded modal choice; greater system redundancy and resiliency; agency cost savings; lower transportation prices from increased competition; and – possibly – reduced energy consumption and air emissions. In practice however, applications of MTA remain limited; and little evidence was found of "*any agencies engaged in a true comparative multimodal analysis process that directly impacts decisions about specific project selection and funding.*" This can be explained by several factors or constraints, grouped within three broad categories: i) inflexibility in federal, state and local funding programs; ii) lack of suitable data, tools and methods for conducting valid comparisons across modes; and iii) a variety of institutional and jurisdictional issues (described as "turf issues and local politics").<br><br>Finally, the paper recognizes that ODOT is further along than most DOTs in terms of data and models to support MTA; and emphasizes Oregon's successful applications of collaborative decision-making processes to transportation planning. |

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| Online | n/a |

| Title | Multimodal Tradeoffs Workshop |
|---|---|
| Authors | Federal Highway Administration; prepared by Cambridge Systematics |
| Date | February 2006 |
| Pages | 73 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★ |
| Abstract | This report provides background information on multimodal tradeoffs processes, extracted from an overview memorandum distributed to various agencies participating at a workshop organized by the Federal Highway Administration in 2005. The goal of the peer exchange was to identify how the agencies address the challenges of managing investment tradeoffs among multimodal systems to achieve policy objectives. The report also contains an outline of the questions participants were invited to address before the meeting, as well as a summary of their answers. The following questions were included: How would you or your agency define a multimodal tradeoff? Does your agency conduct a multimodal tradeoff analysis to address both passenger and freight movement? What tools are used to conduct or make tradeoff decision within modes? Does your agency employ specific tools to conduct multimodal tradeoff analyses (between modes)? How are results from multimodal tradeoff analyses utilized and presented in your agency? One of the main findings of the study was that multimodal tradeoffs are not widespread, but that there was movement and desire to go in that direction. |
| Online | http://www.fhwa.dot.gov/planning/statewide/mmwkshp.htm |

| Title | Virginia's Statewide Multimodal Long-Range Transportation Plan Phase 3 and Final Report to the General Assembly |
|---|---|
| Authors | Virginia Department of Transportation |
| Date | November 2004 |
| Pages | 150 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★ |
| Abstract | This report is the final version of VTrans 2025, Virginia's Statewide Multimodal Long-Range Transportation Plan. It is in this report that VDOT introduces the concept of multimodal investment networks (MIN) and identifies 11 candidates for application. The concept of MIN was subsequently replaced by a closely related concept in VTrans 2035: Corridors Of Statewide Significance, or COSS.<br>Report citations (see part 2 of this appendix): *VTrans 2025- Virginia's* |

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| | *Statewide Multimodal Long-Range Transportation Plan*, Virginia Department of Transportation, November 2004, and *Multimodal Investment Network (MIN) Statement*, Dulles Airport Access Corridor, January 2004.<br>VDOT's VTrans 2035 was selected as a case study candidate for this study. |
| Online | http://www.virginiadot.org/projects/vtrans/resources/revisedPhase3Reportforctb.pdf |

| Title | Development of a Multimodal Tradeoffs Methodology for Use in Statewide Transportation Planning |
|---|---|
| Authors | American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Planning; prepared by Cambridge Systematics |
| Date | October 2004 |
| Pages | 30 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★★ |
| Abstract | This report provides guidance on how to apply a generalized approach for multimodal tradeoff analysis in a real-world situation using data from a state department of transportation. The approach was developed in 2001 by the National Cooperative Highway Research program, and is documented in a separate report. The methodology was applied to two Washington State DOT case studies.<br>The primary finding of the research is that the NCHRP methodology can be applied to real-world situations. The methodology provided a systematic way to gather and organize data, and to present the information in a clear, concise way to staff and decision makers. On the other hand, the research team had difficulty applying the approach to a program-level analysis (in other words, shifting funds from one program to another, such as transit to highways). This was due to the lack of analytical tools able to provide some key pieces of necessary information, rather than a problem with the methodology itself. The missing tool is one that can take project-level performance measure information and "roll it up" to generate program-level information. |
| Online | http://www.transportation.org/sites/planning/docs/nchrp7.pdf |

| Title | Economics of Travel Demand Management:<br>Comparative Cost Effectiveness and Public Investment |
|---|---|
| Authors | Florida Department of Transportation, prepared by the National Center for Transit Research, Center for Urban Transportation Research, University of South Florida |
| Date | March 2007 |
| Pages | 81 pages |
| Category | Conceptions and applications in the U.S. |
| Relevance | ★★ |
| Abstract | The objective of this study is to develop a methodology that combines academic and practitioner experiences within a theoretical framework that captures consumers' price responsiveness to diverse transportation options by embracing the most relevant trade-offs faced under income, modal price, and availability constraints. The development of the theoretical model leads to the design and implementation of TRIMMS (Trip Reduction Impacts for Mobility Management Strategies), a practitioner-oriented sketch planning tool.<br>TRIMMS allows program managers and funding agencies to make informed decisions on where to spend finite transportation dollars based on a full range of benefits and costs. The approach is consistent with other benefit-cost analyses. The model allows some regions to use local data or opt to use defaults from national research findings, select the benefits and costs of interest, and calculate the costs and benefits of a given program. A step-by-step introduction to the program, its capabilities, and a set of working examples to guide the user through the process of evaluation is included in the report. A key strength of the model is the wide range of benefits and costs that can be selected for the analysis. |
| Online | http://www.nctr.usf.edu/abstracts/abs77704.htm |

## Conceptions and Applications Abroad

| Title | New Approach To Appraisal (NATA) Refresh: Appraisal for a Sustainable Transport System |
|---|---|
| Authors | UK Department for Transport (DfT) |
| Date | April 2009 |
| Pages | 72 pages |
| Category | Conceptions and applications abroad (with guidance) |
| Relevance | ★★★★ |
| Abstract | The New Approach To Appraisal (NATA) is a body of advice, software, and data products that the DfT provides to support those developing business cases for government funding or approval. The analytical tools ensure transport interventions are appraised in a comparable and consistent way; and where standardization and best practice is possible, NATA seeks to disseminate it to ensure that analysis is robust and undertaken at proportionate cost.<br>NATA Refresh was launched in October 2007 with the aim of reviewing DfT's appraisal framework. The consultation and associated program of work was started in the light of the recommendations of two major studies (the Stern Review and the Eddington Transport Study). Refresh was based on the notion that by drawing on the experience of people who had used and engaged with NATA through a consultation process, DfT would be able to develop the framework in a way that drew on lessons learned.<br>The five principal themes of Refresh are as follows:<br>• Better capturing of transport policy impacts on productivity and competitiveness; particularly agglomeration and labor market effects in cities, travel reliability, distribution of freight, housing and connectivity<br>• Better capturing of environmental impacts, particularly valuing carbon emissions, landscape impacts, and changes in air quality<br>• Better capturing of equality issues—social inclusion, housing<br>• Ensuring greater comparability across modes and between different types of intervention (for example, taking proper account of the different taxation and financing structures faced by different modes and aligning investment appraisal and regulatory impact assessment)<br>• Better reflecting uncertainties, both in forecasting and in our understanding of valuations and behaviors to aid robust decision making<br>A total of 101 responses to the consultation were received from a wide range of stakeholders. The DfT released a number of changes to its guidance, along with additional advice on specific issues (for example, wider economic impacts, appraisal of housing benefits, analysis of packages of schemes).<br><br>Report citation (see part 2 of this appendix): *NATA Refresh: Appraisal for a Sustainable Transport System,* Department for Transport, April 2009.<br><br>The UK DfT NATA Refresh was selected as a case study candidate for this study. |
| Online | http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/consultations/archive/2008/consulnatarefresh/natarefresh2009.pdf |

| Title | Accessibility Planning Methods |
|---|---|
| Authors | New Zealand Transport Agency, prepared by Booz & Company (New Zealand) Ltd |
| Date | October 2008 |
| Pages | 110 pages |
| Category | Conceptions and applications abroad (with guidance) |
| Relevance | ★★★★ |
| Abstract | Accessibility planning can be defined as a structured process for the assessment of, and planning for, accessibility. It can take many forms, be applied across the entire population or to specific groups, and be undertaken at different spatial levels. Accessibility planning provides a method for assessing access equity as it considers the needs of all groups, including those considered vulnerable to exclusion. It encourages coordination between transport and other public policy objectives, for example, housing, health, and education. Quantitative indicators of accessibility are combined with qualitative surveys in the assessment of planning options for decision making.<br>Report citation (see part 2 of this appendix): *Accessibility Planning Methods,* New Zealand Transport Agency Research Report prepared by Booz Allen & Company (New Zealand) Ltd, October 2008. |
| Online | http://www.nzta.govt.nz/resources/research/reports/363/ |

| Title | Integrated Transport Assessment Guidelines and Supplementary Documents |
|---|---|
| Authors | Auckland Regional Transport Authority |
| Date | October 2007 |
| Pages | 158 pages |
| Category | Conceptions and applications abroad (with guidance) |
| Relevance | ★★★★ |
| Abstract | The fundamental purpose of the Integrated Transport Assessment (ITA) is to provide information on how a proposed development will function in terms of accessibility. The ITA guidelines assist in identifying how a development will interact with existing transportation networks, where traffic capacity constraints may occur, where passenger transport services are sufficient, or where extra services are required and the level of accessibility for walking and cycling. ITA seeks to ensure the integration of land use with all modes of transportation.<br>This report provides guidelines on undertaking a range of appraisals and implementing well-integrated multimodal developments throughout the Auckland region. |
| Online | http://www.arta.co.nz/home/land_use_and_transport_guidelines.html |

| Title | Least Cost Greatest Impact: A Discussion Paper on the Applicability of Least Cost Planning to Transport in Australia |
|---|---|
| Authors | Doreen Chen, Sally Campbell and Stuart White<br>Institute for Sustainable Futures, University of Technology, Sydney |
| Date | November 2003 |
| Pages | 23 pages |
| Category | Conceptions and applications abroad |
| Relevance | ★★★ |
| Abstract | This discussion paper explains the features of least cost planning and its application to transportation. The paper also discusses the ways in which LCP may enhance decision making and includes a case study application from the United States (Destination 2030, by the Puget Sound Regional Council). The four main advantages of LCP are identified as follows: i) LCP incorporates a wider notion of costs and benefits; ii) allows for a flexible transportation system; iii) considers supply and demand-side alternatives together; and iv) encourages a balanced and diverse transportation system. Finally, a brief hypothetical application of LCP in the New South Wales metropolitan area is provided to highlight the potential benefits of the approach. |
| Online | http://www.isf.uts.edu.au/publications/chenetal2003leastcost.pdf |

| Title | Strategic Environmental Assessment |
|---|---|
| Authors | European Union, DG Environment; prepared by Environmental Resources Management |
| Date | January 2001 |
| Pages | 112 pages |
| Category | Conceptions and applications abroad (with guidance) |
| Relevance | ★★★ |
| Abstract | In 1997, the European Commission, in collaboration with five Member States (Austria, France, Italy, Sweden, and the United Kingdom), embarked on a program to develop and test Strategic Environmental Assessment (SEA) of transportation corridors. Five corridors were selected out of the wider Trans-European Transport Network (TEN), once for each participating country.<br>The purpose of this report is to assess the five pilot SEAs, with a view to draw out the most relevant aspects of good practice. The study included a detailed review of the SEA final reports, as well as a series of interviews with selected representatives of the teams involved in the assessments. Its relevancy to LCP centers on the program's objective of identifying the best alternative given equal environmental impact levels. This program explores several means of quantifying environmental impacts so that they can be compared |

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| | equally and easily among alternatives.<br><br>Report Citation (see part 2 of this appendix): *Strategic Environmental Assessment of Transport Corridors: Lesson learned comparing the methods of five Member States,* European Commission, DG Environment, January 2001. |
| Online | http://ec.europa.eu/environment/eia/sea-studies-and-reports/sea_transport2.pdf |

| Title | Multi-criteria Analysis Procedure for Sustainable Mobility Evaluation in Urban Areas |
|---|---|
| Authors | Vania Barcellos Gouvea Campos, et al. |
| Date | September 2008 |
| Pages | 20 pages |
| Category | Conceptions and applications abroad |
| Relevance | ★★ |
| Abstract | This paper proposes a procedure to evaluate sustainable mobility in urban areas. A set of indicators according to three dimensions of sustainability (environment, economics, and social aspects) are proposed to evaluate mobility. Indicators include: resident population within 500 meters from urban public transportation; mean distance to schools; number of private vehicle trips per capita; or proportion of roads with sidewalk.<br>The evaluation is based on an index calculated through a weighted multi-criteria combination procedure. A group of specialists in Brazil defined the weights for the criteria for the index. An application of the methodology in the city of Belo Horizonte, capital of the State of Minas Gerais, with 2.24 million inhabitants, is presented to illustrate the methodology. |
| Online | http://www.ingentaconnect.com/content/ift/joat/2009/00000043/00000004/art00002 |

| Title | Smarter Choices – Changing the Way We Travel |
|---|---|
| Authors | S. Cairns, L. Solman, C. Newson, J. Anable, et al. |
| Date | July 2004 |
| Pages | 379 pages |
| Category | Conceptions and applications abroad |
| Relevance | ★★ |
| Abstract | This report focuses on “soft” transportation policy measures seeking to give better information and opportunities aimed at helping people to choose to reduce their car use, while enhancing the attractiveness of alternatives. Soft measures include: workplace and school travel plans; personalized travel |

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| | planning, travel awareness campaigns, and public transport information and marketing; car clubs and car sharing schemes; and telecommuting, teleconferencing, and home shopping. The report draws on earlier studies, new evidence from the UK and abroad, case study interviews relating to specific initiatives, and the experience of commercial, public and voluntary stakeholders involved in organizing such schemes. Each of the soft factors is analyzed separately, followed by an assessment of their combined potential impact. |
| Online | http://www.dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt/ |

| Title | Evaluation Methodologies of Transportation Project in Japan |
|---|---|
| Authors | H. Morisugi |
| Date | 2000 |
| Pages | 6 pages |
| Category | Conceptions and applications abroad |
| Relevance | ★★ |
| Abstract | This short paper examines the system and manuals for transportation project evaluation introduced in Japan for all transportation modes (road, railway, airport, and seaport). The manuals aim to assess the social value of projects from the viewpoint of efficiency and equity by applying a form of multi-criteria decision analysis, even though cost-benefit analysis principles are used to evaluate efficiency. Results of the review suggest that there are several inconsistencies among key components of the evaluation procedures (such as demand forecasting, value of time, environmental aspects, and regional development effects). These inconsistencies, according to the author, illustrate the difficulties associated with developing a common evaluation framework for multimodal applications. |
| Online | http://ideas.repec.org/a/eee/trapol/v7y2000i1p35-40.html (Subscription Required) |

# 2—Notes on Candidate Case Studies

This section provides a summary of information collected to inform the selection of case studies. This information was gathered prior to the case study selection and is the result of a desktop literature review.

## Sustainable Communities Strategy (SCS)
## California Department of Transportation

California Metropolitan Planning Organizations (MPOs) are required to develop a Sustainable Communities Strategy (SCS), a new element in the Regional Transportation Plan (RTP), to meet the California Air Resources Board (ARB) greenhouse gas emission reduction targets for the automobile and light truck sector.[1] This is relevant to LCP in that the California DOT will be looking at the SCS as a way to better quantify benefits from reducing greenhouse gas emissions, and as a strategy for reducing the emissions themselves.

An SCS includes: (1) a land use component that identifies how the region could house its entire population over the next 8 years and 20 years; (2) a discussion of resources and farmland areas to be protected; (3) a transportation network; and (4) a demonstration of how the development pattern and the transportation network can work together to reduce greenhouse gas emissions to achieve ARB targets.

Preparing an SCS will require MPOs to work with local land use authorities to develop reasonable land use assumptions and other transportation demand strategies. MPOs should quantify, to the extent possible, the co-benefits associated with the achievement of their greenhouse gas reduction targets, as a means of increasing public understanding and support. SCS should also promote the development and use of planning models that can accurately estimate the potential global warming and co-benefits of various land use scenarios in the development of the targets and the SCS.

### Elements of Least Cost Planning

SCS should identify where multimodal transportation investments are needed to achieve the regional GHG reduction targets set by the California ARB.

MPOs may also consider other transportation strategies that reduce GHG emissions. These may include TDM strategies, TSM strategies, transportation investments, and land use strategies.

### Focus Areas

California MPOs are required to include SCS in their RTPs for the purpose of reducing greenhouse gas emissions; aligning planning for transportation and housing; and creating specified incentives for the implementation of the proposed strategies.

1 SCS was added as a new component of Regional Transportation Plans following the passage of SB 375 in September 2008, pursuant to Government Code Section 65080(b)(2).

### Performance Indicators

- **Increased mobility:** congestion relief, more transportation choices, reduced commute time, and increased productivity
- **Economic benefits:** traveler savings, taxpayer savings, neighborhood economic development, and lower up-front infrastructure costs
- **Reduced air and water pollution:** less air pollution and improved water supply and quality
- **Conservation of open space:** acreage of farm land and forest land
- **Healthier, more equitable and sustainable communities**: more opportunities for active lifestyles, less dependence on foreign oil, improved safety, greater housing choices, and more equitable communities

### Reference

California Department of Transportation. 2009. "2010 Working Draft California Regional Transportation Plan Guidelines." November.

## Accessibility Planning

## New Zealand Transport Agency

Accessibility planning can be defined as a structured process for the assessment of, and planning for, accessibility. It can take many forms, be applied across the entire population or to specific groups, and be undertaken at different spatial levels; for example, from transport and land use planning at a regional level down to curb design and public transport vehicle quality standards. Regardless of the level at which it is undertaken, accessibility planning involves the assessment of the location and delivery of key activities and the transport links to and from them.

The assessment of accessibility is the measurement of how easy it is for a traveler to reach a desired activity based on a set of measurable indicators. Accessibility planning provides an understanding of the accessibility characteristics of different origins and destinations and the factors motivating travel behavior, which is very useful for achieving public policy goals in these areas.

### Elements of Least Cost Planning

- It is a form of integrated planning (land use and transportation).
- It focuses the planning process on the requirement for and context of travel by considering the location, design, and delivery of all key services in the area or for the group it is applied to.
- It provides a method for assessing access equity as it considers the needs of all groups, including those considered vulnerable to exclusion.
- It encourages coordination between transport and other public policy objectives, for example, housing, health, and education.

- It provides an additional/alternative method for evaluating the impacts of land use projects or transport service changes, enabling the social implications of these to be fully assessed.
- It has the ability to deliver positive economic and social (and environmental) community outcomes.

### Focus Areas

The main goal of accessibility planning is to improve access to activity centers.

The New Zealand Urban Design Protocol (Ministry for the Environment, 2005) observes that "physical conditions that give access are a combination of urban structure (with connectivity being a key factor), quality of space, and the relative proximity of activities and destinations." Patterns of land use, the nature of the transportation system, and quality urban design are, therefore, fundamental to accessibility.

### Performance Indicators

Quantitative measures are the most common type of accessibility indicators and form the basis of accessibility assessment. Indicators can be grouped into three main categories:

- **Transport system access (TSA) indicators:** Commonly used in New Zealand, these measure private transport (for example, car ownership) and the ease of access to a network, usually the public transportation network (for example, the distance from home to the nearest bus stop or railway station). TSA indicators are useful for providing a picture of access to public transportation and for determining the catchment area of an activity centre.
- **Threshold or opportunity indicators:** These combine travel characteristics (for example, distance, travel time or cost), socio-demographic information, and activity information (for example, number of jobs available at an employment location), to assess levels of access to an activity, or alternatively, the number of activities available to households. Accessibility is expressed as bands or thresholds around an activity centre or residential location.
- **Continuous or gravity-based indicators:** These provide an indication of the relative attractiveness of a location in terms of accessibility to an activity type. Accessibility is calculated as an index, which can be mapped to show varying levels of ease of access. These indices incorporate characteristics of both travel and activities along with a continuous "deterrence function" or weighting, which reflects the deterrent effect of increased distance, travel time, or cost of travel.

Qualitative surveys are used to supplement quantitative measures. They allow for the consideration of factors such as concerns about safety or crime, awareness of the availability of information, limits to travel horizons, and perceptions about the quality of services.

### Reference

Booz Allen & Company (New Zealand) Ltd. 2008. *Accessibility Planning Methods*. Prepared for New Zealand Transport Agency. October.

## Integrated Transport Assessment
## Auckland Regional Transport Authority

The fundamental purpose of the Integrated Transport Assessment (ITA) is to provide information on how a proposed development will function in terms of accessibility. The ITA guidelines assist in identifying how a development will interact with existing transport networks, where traffic capacity constraints may occur, where passenger transport services are sufficient, or where extra services are required and the level of accessibility for walking and cycling. ITA seeks to ensure the integration of land use with all modes of transport.

The key role of the ITA is to ensure that developments are designed and implemented such that they promote access by all modes and manage demand to avoid unacceptable impacts on road networks. According to the Auckland Regional Transport Authority, accessibility is defined as the degree to which people, goods, and services have opportunities to conveniently travel within an area or region. Accessibility can be measured by indicators such as travel times, travel costs, availability of travel opportunities, and the convenience (perceived and actual) of using different transport modes.

### Elements of Least Cost Planning

The ITA guidelines have been developed to ensure that all aspects of transportation are considered and not just the implications for traffic.

ITA helps manage travel demand and identify opportunities for access to integrated high frequency passenger transport services, walking, cycling, and achieving appropriate and supportive parking controls and to ensure sufficient road capacity.

ITA tries to mitigate some of the adverse effects of transportation and create a multimodal development with accessibility for all users.

ITA uses a “multi-criteria assessment” tool based on a framework presenting descriptions of the likely impacts over a wide range of areas. This allows agencies involved to weigh the key impacts and judge whether the benefits outweigh the costs to society, including those that are difficult to estimate.

### Focus Areas

Transportation and accessibility are significant issues facing the Auckland region today. Many of the transportation issues in Auckland are the direct result of incremental land use and transportation decisions, often made in isolation that have not always addressed all modes or adequately assessed the wider and long-term implications of transportation.

### Performance Indicators

The multi-criteria assessment groups impacts under seven main categories, each with sub-categories that may vary according to the type of proposal and its scale:

- **Environment:** noise level, local air quality
- **Safety:** risk of accident, personal security of those using and passing by the site
- **Accessibility:** changes in access to transport systems, community
- **Integration:** links with other policy areas, links between transport system
- **Economy:** effects on the economic efficiency and vehicle operating costs
- Road impact/traffic impact assessments
- Parking impact analysis

### Reference

Auckland Regional Transport Authority. 2007. Integrated Transport Assessment Guidelines and Supplementary Documents. October.

## Strategic Environmental Assessment (SEA)

## European Union

The Trans-European Transport Network (TEN) guidelines, adopted in July 1996, include a general consideration for the environmental implications of European Union policy. They refer to the need to help "achieve the Community's objectives, particularly in regard to the environment" and to the "integration of environmental concerns into the design and development of the network." This is one of the priorities which contribute to a project being considered of common interest. The guidelines call upon the Commission to develop "methods of analysis for strategically evaluating the environmental impact of the whole network" and for "corridor analysis covering all relevant modes of transportation."

In response to the guidelines, the Commission (Directorate Generals for Transport and Energy and for Environment, EuroStat, and the European Environment Agency) engaged in a work program that has produced some important and encouraging results on SEA for the transportation sector. The work program involved:

- Producing a manual of SEA methodology for transportation
- Carrying out a pilot SEA of the overall TEN
- Promoting pilot assessments of TEN corridors by individual Member States involving, where possible, multimodal options
- The main steps undertaken in the SEA process typically include:
- Defining the area of analysis
- Identifying range of impacts
- Defining the reference scenario and minimum impact
- Assessing the minimum impact of all alternatives
- Making all alternatives comparable

- Calculating the cost of each alternative
- Identifying the "best" alternative

### Elements of Least Cost Planning

In identifying the best alternative, SEA considers the option that given equal environmental impact levels will involve the least amount of financial resources to implement.

An SEA should meet the following criteria:

- Be based on quantitative data
- Compare "like with like"
- Guarantee the objectivity of the evaluations
- Compare environmental effects with their financial cost

### Focus Areas

SEA focuses on the environmental impact of the alternatives under consideration.

### Reference

European Commission, DG Environment. 2001. *Strategic Environmental Assessment of Transport Corridors: Lesson Learned Comparing the Methods of Five Member States*. January.

## Multimodal Investment Choice Analysis (MICA)
## Washington State Department of Transportation

Launched in 1999, Multimodal Investment Choice Analysis (MICA) is a computer-based tool being developed to assist WSDOT, the Washington State Transportation Commission, the governor's office, and the Washington state legislature when making state transportation funding decisions. The function of MICA is to summarize the multimodal budgetary choices that will result from varying funding allocation and priority scenarios.

MICA's methodology is based on a combination of cost-benefit and goal achievement analyses. Prioritization between alternative is based on single criterion, multi-criteria, or weighted multi-criteria. The tool can be broken down into three main components: global assumptions, project-level analysis, and scenario-level analysis.

Global assumptions are those variables that must be the same for evaluation of all project types to ensure that projects across all modes are analyzed on an equal basis. Typical global assumptions include discount rate, value of in-vehicle time, and social costs of various types.

Project-level analysis methodology is created around the concept of building blocks or uniform measures. Although the different analysis methods are unique to the project or program type, the output from the analysis is standardized. The project-level analysis outcome includes monetary and nonmonetary impact estimates (user operating impacts, environmental impacts, and safety impacts), project costs, cost-effectiveness measures

(benefit/cost ratio, and net present value), and 17 outcome objectives developed as part of Washington's transportation plan. Scores are calculated for each of the objectives and range between 0 and 100 (with 100 being the best score). The outcome objectives allow decision makers to identify projects for funding that have attributes that are hard to capture in the cost-benefit analysis, but nevertheless represent WSDOT goals. Outcome objectives include preservation, improved security, collaborative decision making, support for tourism, the extent to which water quality standards are met, and so forth.

The scenario-level analysis uses as input, output from the project-level analysis, and additional user inputs to create funding scenarios. The user must select prioritization categories as well as the relative weights of the selected categories (for example: benefit/cost ratio at 65 percent and tourism outcome objective scores at 35 percent). Once the scenarios have been created, the computer tool provides a mechanism by which these scenarios can be compared. The scenario comparison allows the user to examine the relative consequences of varying budget levels and spending priorities. For example, by running two scenarios with identical priorities but different budget levels, the user can see what the additional money buys in terms of minutes of travel time savings, vehicle emissions, or accident cost savings. The outcome scores allow the user to prioritize spending on projects that may not be the most cost-effective in terms of traditional benefit/cost values, but that may address a particular WSDOT concern.

### Reference

Washington State Department of Transportation. 2002. *Multimodal Investment Choice Analysis*. June.

## Multimodal Investment Network (MIN)
## Virginia Department of Transportation (selected for case study)

The MIN approach to planning involves considering MINs both as a concept (improving multimodal linkages) and a process (describing how the state identifies multimodal solutions and works with its planning partners to craft and implement MINs).

MINs are typically composed of projects from several modes. For example, the Interstate 81 Passenger and Goods Movement MIN is composed of recommendations for capacity improvements along Interstate 81, freight and passenger rail capacity improvements, and a new community airport in Lexington/Rockbridge County.

As a process, planning around MINs provides a mechanism for ensuring that multimodal solutions are identified. The four transportation modal agencies (road, air, water, and transit) identify opportunities for substitutability and intermodal needs. While one modal agency takes the lead in championing the MIN, all the agencies are represented in the identification and evaluation of multimodal needs. This is different from the current planning processes. There is now a shift from focusing on individual modal capacity issues to focusing on the most efficient way to move people and goods throughout the state. In this way, long-range planning is more likely to result in a more integrated transportation system and more multimodal solutions.

### Elements of Least Cost Planning

- MIN maximizes system utilization by increasing the efficiency of existing facilities and services through the use of technology and demand management techniques.
- MIN involves identifying opportunities where one mode might be a more effective solution than another, while still in the planning stage.
- The multimodal planning practices are "modally blind." The planning process used evaluates the merit of all modes on an equal footing and is not biased toward a specific mode. Further, all modes are analyzed simultaneously, and interactions between modes are examined.
- MIN allows for the use of performance measures that allow for cross-modal comparison and a less biased assessment of needs and alternatives.

### Focus Areas

The emphasis is on creating an interconnected transportation network: identifying projects where one mode relies on another, intersects with another, or might substitute for another mode.

### Performance Indicators

- Reduction in long-term capital cost
- Reduction in time to clear nonrecurring events; on-time performance of system and services; reduction in travel time variability; reduction in unexpected delay
- Number of modes serving activity center; frequency of service to activity center
- Number of alternatives to highway travel
- Reduction in VMT; level of service improvement; reduction in travel delay

### References

Dulles Airport Access Corridor. 2004. "Multimodal Investment Network (MIN) Statement." January.

Virginia Department of Transportation. 2004. *VTrans 2025 – Virginia's Statewide Multimodal Long-Range Transportation Plan*. November.

## New Approach to Appraisal (NATA)

## UK Department for Transport (selected for case study)

NATA is a body of advice, software, and data products that the Department for Transport provides to support those developing business cases for government funding or approval. The analytical tools ensure transport interventions are appraised in a comparable and consistent way.

NATA has evolved since its origin in 1998. The latest version, "NATA Refresh: Appraisal for a Sustainable Transport System," was released in April 2009. It is now the basis for:

- Appraisal of multimodal studies

- Appraisal of Highways Agency road schemes and local transport plans
- Major road and public transport schemes
- The project appraisal framework for seaports
- The appraisal process employed during the development of the government's airports strategy

NATA includes the identification and assessment of problems, identification of options, and assessment of those options. Throughout this process, the approach works within the general framework provided by the government's five goals for transportation: reduce emissions of carbon; support economic growth; promote equality of opportunity; improve quality of life and promote a healthy, natural environment; and contribute to better safety, security, and health.

### Elements of Least Cost Planning

NATA takes account of all the economic, social, environmental, and financial impacts of an intervention. NATA recommends that options should be appraised using cost-benefit analysis, with supplementary techniques to be used for weighing up those costs and benefits that remain unvalued (for example, multi-criteria decision analysis). It defines cost-benefit analysis as an "analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible including items for which the market does not provide a satisfactory measure of economic value."

### Performance Indicators

- **Environment:** noise levels, greenhouse gas emissions
- **Safety:** accidents, security
- **Economy:** public accounts, transport economic efficiency (impacts on business users, transport providers, and consumers)
- **Accessibility:** option values, severance, access to the transport system
- **Integration:** transport interchange, land use policy

### Reference

Department for Transport. 2009. *NATA Refresh: Appraisal for a Sustainable Transport System*. April.

## Least Cost Planning Analysis

## Puget Sound Regional Council (selected for case study)

In the State of Washington, beginning July 1, 2000, all regional transportation plans developed by Regional Transportation Planning Organizations in Washington state were required (RCW 47.80.030) to be "based on a least cost planning methodology that identifies the most cost effective facilities, services, and programs." Within Washington Administrative Code (WAC 468-86-030 and WAC 468 -86-080) least cost planning is defined as "a process of comparing direct and indirect costs of demand and supply options to meet

transportation goals and/or policies where the intent of the process is to identify the most cost-effective mix of options." LCP attempts to consider all of the resource costs associated with alternative investments, and to provide information relevant to decisions about investment selection and prioritization. LCP combines elements of strategic, systems-level planning within the accounting framework of cost-benefit analysis.

There are two major components to a LCP process. The first step is the identification of alternative transportation scenarios or investment packages. This is essentially a strategic planning exercise. The second is the estimation and comparison of costs and benefits associated with these different alternatives. This is essentially a simplified cost-benefit analysis modified to assist the evaluation of transportation planning alternatives.

## References

Puget Sound Regional Council. 2000. "Least Cost Planning: An Analysis of Metropolitan Transportation Plan Alternatives." October.

Washington Department of Transportation. 2009. "Least Cost Planning Guidance." October.

# Appendix C
# Efforts to Quantify Traditionally Intangible Criteria

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APPENDIX C

# Efforts to Quantify Traditionally Intangible Criteria

In this appendix, we provide details from desktop and case study research related to how some agencies quantify selected traditionally intangible criteria, or benefits. The discussions illustrate approaches needed to address intangible (or "soft") costs which will be identified in subsequent phases of Oregon's least cost planning efforts. The methods summarized below are not necessarily the ones most appropriate to Oregon; that needs to be determined at a later time. They are, however, intended to illustrate useful, peer-reviewed approaches for monetizing many issues and benefits found to be important to stakeholders in other studies and places around the world.

The illustrative criteria include:

- Regeneration
- Benefits from logistic reorganization
- Health benefits of new cycling and walking facilities
- Social and distributional impacts
- Housing development benefits
- Agglomeration benefits
- Improvements in travel time reliability

In the sections below, we provide a brief description of each criterion or benefit, an overview of the methods used—or considered—by agencies for quantification, and a reference for further information.

## Regeneration

The impacts of transportation investments may not be evenly distributed across a region or state. For example, increased employment may be felt in some areas while equivalent reductions occur in others, with no net regional or statewide impact. This example is particularly relevant in so-called "Regeneration Areas" (UK), or "Economically Distressed Areas" (United States), for which a policy objective of increasing economic activity has been set. Where it is the case, it may be desirable to introduce plans or measures that increase local employment, even if this leads to reduced employment elsewhere.

Regeneration "benefits" can be measured by the change in total employment or by the change in the number of jobs created in that area. This is achieved through a detailed analysis of how the local economy operates, why it is stagnant or in decline, and how the proposed transportation investment may contribute to reversing the decline (by improving access to existing employment opportunities, or reducing transportation costs for businesses).

Additional information on regeneration benefits can be found on the UK Department for Transport website at: http://www.dft.gov.uk/webtag/documents/project-manager/unit2.8c.php.

## Benefits from Logistic Reorganization

The Federal Highway Administration has recently made strides towards determining the appropriate approach to the measurement of benefits associated with logistic reorganization. These benefits have been described as improved ability to rely on "just-in-time" input management or to reduce warehousing inputs, as the freight system becomes more reliable.

The approach developed by FHWA consists of estimating the long term relationship between the demand for freight on one hand, and generalized shipping costs and highway level of service on the other. It is based on the premise that logistic reorganization resulting from reductions in transportation costs would increase the demand for shipping (measured in truck miles) and would expand the "surplus" of shippers (as consumers of transportation services) beyond what is estimated in conventional benefit-cost analyses. This expansion is summarized by a "premium" (profit, income and/or employment) estimated to range between 5 and 15 percent.

Additional information on reorganization benefits can be found on the Federal Highway Administration website at:
http://ops.fhwa.dot.gov/freight/freight_analysis/econ_methods/bca_logistics/index.htm.

## Health Benefits of New Cycling and Walking Facilities

Cycling and walking schemes are likely to have a positive effect on physical fitness and health where new or extended trips are generated (either where these trips were formerly made by motorized means, or were not made at all). Improvements in health will manifest themselves most meaningfully through reduced rates of mortality.

The method recommended by the UK Department for Transport (DfT) for estimating these benefits is taken from the World Health Organization project "Quantifying the Health Effects of Cycling and Walking (2007), and its accompanying model, the "Health Economic Assessment Tool" (HEAT) for cycling. It involves calculating the number of preventable deaths per person taking up moderate physical exercise through walking or cycling; and makes use of the Value of Statistical Life (VSL) recommended by DfT. The change in the number of preventable deaths itself is based on a report by the Copenhagen Centre for Prospective Population Studies, which found that individuals that cycle for 3 hours per week reduce their relative risk of all-cause mortality to 72%, compared to those who do not commute by cycle.

Benefits from reduced absenteeism due to improved health are also considered by DfT.

They are based on the following findings and assumptions:

- In the U.S., physical activity programs involving 30 minutes of exercise a day have been shown to reduce short-term sick leave by between 6% and 32% (World Health Organization, 2003).
- In the UK the average absence of employees is 6.8 days, of which 95% is accounted for by short-term sick leave (Confederation of British Industry, 2003).
- Therefore, for each employee who takes up physical exercise for 30 minutes a day for 5 days a week as a result of a walking or cycling intervention, the annual benefit to employers is likely to be at least 0.4 days gross salary costs (6% of 95% of 6.8 days), on average.

Additional information on health benefits can be found on the UK Department for Transport website at: http://www.dft.gov.uk/webtag/documents/expert/unit3.14.php#0110.

## Social and Distributional Impacts

The UK Department for Transport has recently commissioned a study to improve the assessment of social and distributional impacts (SDI) within the New Approach to Appraisal (Section 3 of this Discussion Paper). The approach recommended by the consulting team includes several steps, as follows:

- Identify the likely SDI indicators that will require appraisal (for example, distribution of noise, distribution of air quality, accessibility, severance, affordability and financial impacts, distribution of user benefits, personal safety, and road safety)
- Select the spatial levels appropriate to each indicator
- Identify social groups (by income, age, gender, ethnicity/faith, etc.) in areas affected by the transportation plan or project
- Perform a full screening of impacts and social groups; including whether the scale, significance and degree of spatial or socio-demographic concentration of impacts warrant a full appraisal or not

Following these steps, a core appraisal process is conducted for each of the selected indicators, to generate technical data for use in the analysis (for example, exposure to noise; risk of death or injury). The analysis itself is summarized in a matrix of social and distributional impacts, where quantitative indicators or qualitative scores are assigned to each social group under consideration. An example of such matrix, focusing on local air quality, follows.

**TABLE 1**

Example of Air Quality SDI Analysis

| | IMD Income Domain<br>Most deprived areas ◆ Least deprived areas | | | | | **Total** |
|---|---|---|---|---|---|---|
| | 0-20% | 20-40% | 40-60% | 60-80% | 80-100% | |
| No of properties with improved air quality [A] | 400 | 800 | 200 | 0 | 200 | 1,600 |
| No of properties with no change in air quality [B] | 300 | 400 | 100 | 200 | 200 | 1,200 |
| No of properties with worse air quality [C] | 100 | 150 | 150 | 50 | 150 | 600 |
| No. of net winners / losers [D] = [A] – [C] | +300 | +650 | +50 | -50 | +50 | - |
| Total number of Winners / Losers across all groups [E] = ∑[D] | - | - | - | - | - | 1,000 |
| Net winners/losers in each area as % of total [F] = [D] / [E] | 30% | 65% | 5% | -5% | 5% | 100% |
| Share of Total Pop'n of Study Area | 22% | 25% | 15% | 28% | 10% | 100% |
| Assessment (see para 3.5.7 for details) | ✓✓✓ | ✓✓✓ | ✓ | ✗✗✗ | ✓ | ✓✓ |

*S*ource: The Local Air Quality Sub-objective, TAG Unit 3.3.3, Department for Transport, Transport Analysis Guidance, Table 3 page 18

Additional information on social and distributional impacts can be found on the UK Department for Transport website, at:
http://www.dft.gov.uk/webtag/documents/expert/unit3.17d.php

# Housing Development Benefits

The UK Department for Transport (DfT) and Department for Communities and Local Government (CLG) have recently developed a methodology to capture the benefits generated by new housing developments, for inclusion in the New Approach to Appraisal. Of special interest are situations where transportation investments "unlock" housing development; that is, where the development directly depends upon implementing the proposed investment (due to a lack of access to the planned area of development; or to planning constraints arising from an expectation that the surrounding transportation network would be over capacity during peak periods were the new development to proceed).

The benefits of the dependent new homes are estimated in two steps: i) estimating the "planning gain" arising from the new homes; and ii) subtracting the net external costs caused by the new homes.

The planning gain is the "private benefit" associated with the change in land use, as represented by the uplift in land value arising from the decision to grant planning permission for that development. This uplift is defined as the value of the land in its new use (residential) minus the value of the land in its existing use (e.g. agriculture). Property market reports from the Valuation Office Agency (VOA) are used in this assessment.

Net external impacts of the resulting development include gains or losses in the amenity value of land compared to its existing use; and transport-related external costs. The former are based upon estimates of the external benefits of undeveloped land (e.g., landscape, cultural heritage recreation) summarized in a 2004 report for CLG (formerly ODPM, Office of the Deputy Prime Minister).

Additional information on housing benefits can be found on the UK Department for Transport website at: http://www.dft.gov.uk/webtag/documents/expert/unit3.16d.php

Additional information on valuing the benefits of undeveloped land can be found on the Department for Communities and Local Government Web site at: http://www.communities.gov.uk/archived/publications/planningandbuilding/valuingbenefits

## Agglomeration Benefits

Agglomeration benefits are "positive externalities" derived from the spatial concentration of economic activity. They arise through increases in the "effective density" of a location (defined as total employment in and around the area, weighted by their proximity to the location—where proximity is measured in terms of generalized travel cost, not distance). As effective density increases, firms and workers are expected to become more productive, as a result of knowledge spillover, labor market pooling, specialization, or efficient input-output sharing (e.g., reduced delivery times).

The agglomeration consequences of a transportation project or plan will have two components. One will always be positive: a transportation improvement will bring people and firms closer together (in terms of travel time between the firms' locations). The other could be positive or negative: positive if it encourages increased employment in cities or "clusters" of economic activity; and negative if it encourages the dispersion of activity (firms or workers relocating as a result of declining travel costs).

Agglomeration benefits can be measured using estimates of the elasticity of total productivity with respect to the density of employment in an area (by industry); the change in the effective density of employment in the area due to the project or plan; and the area Gross Domestic Product.

Additional information on agglomeration economies can be found on the UK Department for Transport website at: http://www.dft.gov.uk/pgr/economics/rdg/webia/webmethodology

# Improvements in Travel Time Reliability

Travel time reliability can be defined in terms of how much travel times vary over time (for example, hour-to-hour, day-to-day). Variability in travel times from one period to the next is due to the fact that underlying traffic conditions vary, and may therefore be associated with a variety of factors (special events, traffic incidents, weather, work zones, etc.).

The Federal Highway Administration has identified a number of measures of reliability, including: the planning time; the planning time index; and the buffer index. The planning time is the total time needed by travelers to ensure a high rate of on-time arrival. It is typically defined as the 95th percentile of the distribution of travel times. The planning time index is the ratio of the planning time to the "free flow" or ideal travel time. The buffer index, finally, is the ratio of the buffer (planning time minus average travel time) to the average travel time.

The standard deviation of travel times (a synthetic measure of dispersion around the average travel time) is also commonly used as a measure of reliability.
Surveys of car travelers–where travel time reliability was defined in terms of standard deviations–have produced estimates of the value of reliability (VOR) of about 0.8 to 1.3 times the value of time (VOT). In other studies, where variability was defined as the difference between the 90th and 50th percentiles of the distribution of travel times, VOR was of the same magnitude as VOT. Survey findings for commercial vehicles suggest that the willingness-to-pay of freight carriers–and shippers–to reduce travel time variability may exceed their willingness-to-pay for reductions in average travel time (by a factor of 2 to 3).

Additional information on travel time reliability can be found on the Federal Highway Administration website at: http://ops.fhwa.dot.gov/congestion_report.

# Appendix D
# Reference to Least Cost Planning from Oregon Transportation Vision Committee's Report to the Governor

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APPENDIX D

# Reference to Least Cost Planning from Oregon Transportation Vision Committee's Report to the Governor

In November 2008, the Oregon Transportation Vision Committee presented its report to Oregon Governor Kulongoski on how to make an investment in the transportation system that creates jobs, a sustainable environment, and expanded transportation choices for all Oregonians. The Vision Committee was composed of business leaders, legislators, local and state officials, transportation stakeholders, and sustainability and land use experts. Key among their recommendations was one to implement least cost planning. Below is the language from the Vision Committee's report as it relates to least cost planning (pages 3-4, Oregon Transportation Vision Committee's Report to the Governor).

## Implement Least Cost Planning

Oregon Congressman Peter DeFazio, member of the House Transportation and Infrastructure Committee and chair of the House Subcommittee on Highways and Transit, has said he intends to develop the next federal transportation reauthorization bill around the "least cost planning" model. Oregon could also make good use of this proven tool in transportation, acting in advance of a federal requirement. The Vision Committee recommends ODOT begin developing a least cost planning model for use by the state, metropolitan planning organizations (MPOs), and local governments to optimize critical investments in transportation while addressing climate change, and other environmental issues critical to Oregon's quality of life. Collaboration between ODOT, MPOs, and the local governments is essential to implementing least cost planning because of the strong relationship between land use and transportation.

"Least cost planning" is a concept, developed for the electric utility industry that analyzes the methods and costs of taking actions to increase supply while at the same time analyzing the methods and costs of taking actions to decrease demand, and then linking these to transmission and power system management choices. This broadens the scope of potential choices for meeting service requirements. The least cost planning framework has the potential to substantially improve transportation planning in terms of economic efficiency while integrating environmental considerations into the planning process with greater transparency. The goal is to better support informed decision making and accountability. However, application of least cost planning needs to be structured by the defining characteristics of the transportation sector. In transportation, a LCP approach would allow, for example, evaluation of alternatives that increase capacity while also considering alternatives that reduce congestion. In addition to evaluating no-build alternatives, least cost planning also allows for objective consideration of other important policy goals such as reducing carbon output, addressing climate change, supporting economic viability, and enhancing system reliability.

There are fundamental differences between transportation planning and electric utility planning. With transportation, the focus is primarily on movement, but interaction with vehicles, fuels, and facility use is essential. Both applications rely on comparing scenarios that seek to optimize for achieving multiple values rather than any single value, while minimizing risks. An important lesson from the utilities is that there does not appear to be one best way to do least cost planning. Rather, it is important to broaden the range of options considered to achieve transportation objectives and to generate information on the cost and effectiveness of various alternative investment and operations scenarios in transportation.

In least cost planning, different resource and delivery system scenarios (not individual projects) are developed, assessed for costs, and compared. The development of options or scenarios would need to encompass modal choices, geographic areas, and the relevant planning horizon. Additional considerations include the quality of transportation service; the costs and availabilities of fuels and vehicle technologies; current and desired future land uses; environmental goals and limitations; and the network aspect of the system (recognizing that the value of any one segment of a transportation mode is dependent on the availability and quality of other segments; a related issue is that there must be some understanding of the inter-relationships among modes: aviation, transit, rail, highway, bike, and so forth). Finally, the scenarios must take into account the availability of funding and the cost of achieving certain outcomes. Environmental costs that cannot be monetized or quantified are still explicitly weighed in developing scenarios. For example, the scenarios could encompass the full range and needs of the MPO or local government rather than focusing on any specific project; but specific projects would need to be consistent with the proposed scenarios. If the scenario operates under a greenhouse gas reduction constraint, that constraint would function as a limiting factor in scenario design (as minimum safety requirements might, for example).

There are aspects of least cost planning that exist in the current planning processes at both the state and local levels. The application of this concept to the provision of transportation services is now strongly supported by the Oregon Transportation Plan and the Oregon Highway Plan. The Oregon Transportation Plan also endorses the cost minimization and cost effectiveness principles. However, additional work is needed to develop a least cost planning model and use it as a decisionmaking tool in the selection and development of plans and projects, and to make it accessible and available for MPO-level planning.