LEAST-COST TRANSPORTATION PLANNING IN ODOT

Phase 2 Final Report

By

Anthony M. Rufolo
Lois Martin Bronfman
James G. Strathman

Center for Urban Studies
School of Urban and Public Affairs
Portland State University
Portland, Oregon 97207

and

Edward L. Hillsman
Steven R. Elliot

Energy Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

Prepared for

Oregon Department of Transportation
Salem, Oregon 97310

May 1996

Technical Report Documentation Page

1. Report No. FHWA-OR-RD-96-08	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Least-Cost Transportation Planning in ODOT Phase 2 - Final Report		5. Report Date June 1996
		6. Performing Organization Code
7. Author(s) Anthony M. Rufolo, Lois Martin Brofman, James G. Strathman, Edward L. Hillsman, and Steven R. Elliot		8. Performing Organization Report No.
9. Performing Organization Name and Address Center for Urban Studies School for Urban & Public Affairs Portland State University Portland, OR 97207 and Energy Division Oak Ridge National Laboratory Oak Ridge, Tennessee 37831		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. SPR 5267
12. Sponsoring Agency Name and Address Oregon Department of Transportation Research Unit 2950 State Street Salem, OR 97310 and Federal Highway Administration 400 Seventh Street SW Washington, D.C. 20590		13. Type of Report and Period Covered Final Report 1995-1996
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This project is intended to suggest ways in which least-cost planning principles could be incorporated into the transportation planning process. The Mt. Hood corridor was chosen for examination. The examination of the planning process highlighted several differences between a least-cost planning approach and the present process. First, the corridor chosen is designated as an Access Oregon Highway, and this designation sets certain level of service standards that do not appear to be consistent with a least-cost planning process. Second, the analysis of future outcomes was not as detailed as might be required for a least cost planning process. Third, the process was more deterministic than would be expected with least cost planning, since the latter emphasizes uncertainty in forecasts and the need for flexibility. Fourth, the range of alternatives considered appeared to be more narrowly defined than one would find with least cost planning, and fifth, the analysis of travel patterns and possible diversion to other routes was not extensive as might be done for least cost planning. Many of these constraints were due to specific requirements of the planning process or of the environmental process.

Various approaches to evaluating alternatives for the Mt. Hood corridor are detailed and discussed. The types of data needed and the likely cost of the analysis are specified for different approaches. These include cost-benefit analysis, cost-effectiveness or problem-oriented analysis, and estimation of decision-maker preferences.

It is concluded that the general concept of Least-Cost Planning is readily adaptable to transportation planning; however, the specific methodology is still not well-defined and there are substantial knowledge gaps regarding the effect of various policies. In particular, there is little information on the effectiveness of various non-construction alternatives in responding to increases in demand for transportation services.

It appears to be both feasible and desirable to move in the direction that has been identified as "Least-Cost Planning, characterized as a planning process that seeks to improve the efficiency of the transportation system, primarily by considering alternatives to new construction as methods to provide transportation services. Demand management systems, pricing systems, and land use systems are among the options that should be evaluated along with road construction, transit construction, and other supply oriented management systems.

17. Key Words Least-Cost Planning, Integrated Resource Planning, Supple Side Management, Demand Side Management, Transportation, Project Utilization		18. Distribution Statement Available through the Oregon Department of Transportation Research Unit	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

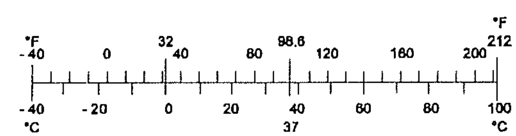
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the guidance of Dave Lutz, the ODOT manager of this project, and numerous helpful comments from the Technical Advisory Committee, including Bob Cortright, Nick Fortey, Cam Gilmour, Brian Greber, Loyd Henion, Tom Hibbard, Mike Hogland, Marty Laylor, Steve Kale and Sam Sadler.

DISCLAIMER

EXECUTIVE SUMMARY

Least-cost planning or integrated resource planning is a process used in the electric utility industry to broaden the scope of choices to meet service requirements. The Phase 1 report for this project evaluated the feasibility of adapting least-cost planning principles to transportation planning. The report concluded that while least-cost principles are applicable to transportation planning, the methods used in the utilities could not be readily adapted.

This phase of the project is intended to suggest ways in which least-cost planning principles could be incorporated into the transportation planning process.

As summarized in the table below, the Phase 1 report identified four important differences between transportation planning and electric utility planning that substantially affect the ability to adapt the process from the utilities to transportation planning. First, the level of consumer satisfaction with the method of service provided is more of an issue in transportation than in the provision of electricity. Most least-cost options in the utility industry, especially those relating to non-business consumers, do not change the level of service that the customer receives, they just change the amount of electricity used in achieving the customer's service goals. For example, customers typically do not care whether the comfort level in homes is achieved by generating more electricity, by improving home insulation, or by using more efficient heaters and air conditioners. Transportation, especially personal transportation, involves many characteristics that customers do value, such as flexibility, comfort, and time. Hence, evaluation techniques must be sensitive to customer satisfaction with the method of service provision.

Second, use of the transportation system is affected by the quality of the service provided. Delays caused by congestion of roads or mass transit systems may cause changes in travel patterns. Reducing these delays then may increase the number of people using the system. These changes in the quality of service are less likely to occur because of choices made regarding provision of electricity. The evaluation techniques must be sensitive to potential users of the transportation system, or those diverted from using it because of service quality.

Third, each transportation mode has system or network characteristics that make it less feasible to treat parts of the system in isolation. These network components are not of great importance in evaluating electricity generation or consumption, but they are in evaluating transportation. In particular, some demand management options that might be considered at the mode level are largely precluded if the analysis is done at the project level. For example, Oregon is currently considering the effect of land-use decisions on the transportation system and vice versa. However, certain options relating to land use, such as increased density, may not be effectively evaluated as alternatives to specific road improvements. Increased density in a particular area is likely to increase the demand for road capacity in that area even if it reduces the demand overall. Hence, evaluating the land-use option relative to a specific road improvement option may generate different conclusions than comparing the options at a more aggregate level.

Fourth, electricity planning is done with the expectation that all of the electricity required will in fact be provided. In transportation planning, different levels of service associated with different funding levels are routinely analyzed. Also, because many transportation demand management options raise revenue, the impact of changes in revenue must be considered.

Table 1: Key Differences Between Electric Utilities and Transportation

Issue	Electric Utilities	Transportation
Consumer Satisfaction	Maintained or improved. Service goals are usually achieved.	May change in either direction. Time, flexibility, and other characteristics of the service are affected by the policies chosen.
Service Quality	Amount of electricity used is seldom affected by service quality (e.g., "brown-outs") for residential users. Goal is for quality to be independent of usage.	Quality of service is an integral part of the planning process. Changes in quality affect usage.
Project v. Modal System	Most supply and demand options are largely independent of each other (e.g., an insulation program does not affect costs or benefits of most other options).	Each segment of the modal system affects other segments (e.g., eliminating a bottleneck at one point may create bottlenecks elsewhere in the system).
Level of Service	Expected to provide all electricity demanded at prevailing price in most circumstances.	Funding level determines the amount of service provided. Projects compete for budget. Some DSM options may raise revenue.

A key part of the analysis in Phase 2 is to carefully document the transportation planning process used in a specific project, with the Mt. Hood corridor from Rhododendron to State Highway 35 chosen for examination. The examination highlights several differences between a least-cost planning approach and the actual process used in this corridor. First, the corridor chosen is designated as an Access Oregon Highway, and this designation sets level of service requirements that do not appear to be consistent with a least-cost planning process. Second, the analysis of future outcomes is not as detailed as might be needed in a least-cost planning process. Third, the process is more deterministic than would be expected with least-cost planning, since the latter emphasizes uncertainty in forecasts and the need for flexibility. Fourth, the range of alternatives considered appears to be smaller than one would find with least-cost planning, and fifth, the analysis of travel patterns and possible diversion to other routes is not as extensive as might be done for least-cost planning. Further, many of these constraints are due to specific requirements of the planning process or of the environmental impact review process.

General approaches to evaluating alternatives for the Mt. Hood corridor are then presented and discussed. The types of data needed and the likely cost of the analysis are specified to identify some of the strengths and weaknesses of different approaches. These include cost-benefit analysis, cost-effectiveness or problem-oriented analysis, and estimation of decision-maker preferences.

In general, least-cost transportation planning can be characterized as starting from the basics of cost-benefit analysis and including consideration of a wide range of alternatives, uncertainty, and flexibility. It appears that the transportation planning process could be changed to incorporate least-cost planning principles, but that there is not a clear-cut set of changes that will accomplish this. Rather, there are a series of issues that must be addressed within the planning process.

While it is clearly an oversimplification, the current transportation planning process focuses on meeting service requirements. This focus tends to limit consideration of alternatives to construction. In particular, the limited budget for construction means that transportation projects that meet level of service requirements in specific areas may not be the best use of available funds. Rather, more explicit consideration of the benefits and costs of construction and other options may indicate that many small projects generate greater net gains than a smaller number of big projects; but none of the smaller projects may meet the relevant service standards.

Hence, the first change needed is more explicit balancing of costs and benefits when allocating transportation resources. This does not mean that formal cost-benefit studies are needed, but rather that a screening mechanism that incorporates costs and benefits be adopted.

The second change is to more explicitly consider non-construction alternatives and to find an evaluation method that considers these alternatives on an equal basis with construction alternatives. At present, incomplete and unreliable information regarding the effectiveness of alternatives limits their consideration. The electric utilities responded to similar gaps by conducting experiments that were carefully evaluated. The knowledge gained from these experiments forms a substantial part of the least-cost planning process in the utilities, and a similar effort will be needed for transportation if least-cost principles are to be effectively applied.

The third change is to more explicitly consider the possibility that transportation requirements and policies will be substantially different in the future. Current planning practice is based on projections of current trends, but the investments being made are intended to last for long periods, when the trends may have changed. In particular, the utilities explicitly plan for future changes in the demand for electricity and for flexibility in meeting changing conditions. More consideration of such possibilities are likely to change the relative desirability of various approaches to meeting transportation needs.

The following actions are recommended for consideration in attempting to adapt least-cost principles to transportation planning:

- Evaluate the impact of laws and service standards. Constraints implied by legal restrictions and service standards may impose substantial obstacles to least-cost outcomes.

- Specify screening criteria. While full cost-benefit studies are not likely to be cost-effective, some criteria must be developed to allow this type of screening.

- Expand the set of alternatives considered. Methods to expand the types of actions evaluated and to compare them to construction options on an equal basis must be developed.

- Fund and evaluate demand-management and other alternatives to construction on an experimental basis.

- Specify the relationship between the different types of planning and the methods to incorporate findings from "higher level" planning into more specific applications. For example, analysis of specific projects may not be able to adequately consider effects on the whole transportation system, but methods to incorporate these effects into the project analysis may affect the choices made.

It is recommended that the least-cost planning process be used differently in the three distinct parts of the transportation planning process. At the state system level, analysis of laws and planning rules in the context of least-cost principles should be a high priority. Further, analysis at this level appears to be closest to cost-benefit analysis with some modifications to address uncertainty and flexibility. The analysis at this level should then lead to a modification of the incentives and constraints placed on lower levels of transportation planning.

At the corridor and metropolitan planning organization (MPO) levels, the emphasis for implementing least-cost planning should be on identifying and evaluating alternatives to construction. Emphasis should also be placed on developing methods that can objectively compare construction and non-construction alternatives. Some evaluation of costs and benefits would still be needed for prioritization, but poor understanding of the effects of many demand-side management and land-use options requires that better information be generated before full evaluations take place. As this information is generated it could be used in other corridor and MPO plans and might also lead to re-evaluation of alternatives at the state system level.

Finally, at the project level, cost-benefit appears to be less relevant to least-cost planning. At this level, the requirements of fitting into the system are likely to outweigh broad evaluations of costs and benefits of options. Rather, appropriate weighting schemes must be developed to create incentives to follow least-cost activities with respect to other state, regional and local policies. For example, higher priority might be given to roads in areas that meet density goals or that use impact fees to fund local infrastructure. Least-cost principles would still argue for some consideration of efficiency objectives, but most such objectives should be met by conforming to the plans specified at higher levels.

LEAST-COST TRANSPORTATION PLANNING IN ODOT
Phase 2 Final Report

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 FEASIBILITY AND IMPLEMENTATION ISSUES

This report suggests how the principles of least-cost planning might be incorporated into the transportation planning process in Oregon. It represents a continuation of the analysis introduced in "Least-Cost Transportation Planning in ODOT: A Feasibility Report." The earlier report identified similarities and differences in least-cost planning for electric utilities and transportation. This report attempts to place some of these issues into a more precise context by examining a specific project, suggesting ways in which the process might have been different if analyzed from a least-cost perspective, and then offering some suggestions as to how the process might be developed to be more consistent with least-cost principles.

The transportation planning process in Oregon is in many ways quite complex. In addition to federal regulations and the usual set of considerations in transportation planning, Oregon's land-use laws also affect the transportation planning process. Many of these constraints on the planning process are fully consistent with least-cost planning as a process, but some are not. Even where the principles are consistent with the objectives, specific procedures that must be followed in implementation may not be. Given the complexity of the transportation planning process, there are two specific warnings. First, it will not be easy to alter Oregon's transportation planning process because of the inter-relationships among its various parts. Second, while many goals are consistent with least-cost principles, there are many that are not, and some consideration must be given to methods to address the inconsistencies.

1.1 REVIEW OF ISSUES

Least-cost planning (LCP) or integrated resource planning (IRP) is used in the electric utility industry to broaden the scope of choices to meet service requirements. Rather than focus exclusively on building additional generating capacity to meet expected demand, utilities also consider methods to reduce the demand for electricity. These are typically referred to as demand-side management (DSM) programs. The basic procedure is to identify supply options to meet expected requirements, identify DSM options, and then pick the least costly combination of supply-side and demand-side options. To make this comparison, many utilities calculate a standardized unit cost of electricity, called the levelized cost of each option. The levelized cost is the cost of generating electricity for supply options or the cost of reducing the amount of electricity needed for demand options. This calculation makes comparisons across widely different options more consistent. While choosing options with the lowest levelized cost is one aim of the utilities, other factors enter into the final mix of options chosen.
Evaluation of the literature on least-cost planning and interviews with utilities using LCP or IRP indicate that the process is far from a uniform or mechanical one. There are a variety of criteria that are used in defining cost and a large array of issues other than cost that enter into the final mix of options chosen. Further, the methodology has evolved gradually over a long time period

and relies on a large number of studies that have been done to evaluate the effectiveness of various demand-side options. The basic economic rationale for least-cost planning in the utilities is that customers were being charged a price for electricity that was below the cost of generating additional electricity. Because customers were not paying the full cost of adding to capacity, they had a tendency to use more electricity than would be efficient. Hence, some investments to convince customers to use less electricity would be less costly than generating the additional electricity. In this respect, there are clear parallels between the situation the utilities have faced and the current situation in transportation.

A number of issues were raised in the feasibility report. The first is the lack of a clear consensus on what least-cost transportation planning really is. While many early proponents of least-cost transportation planning pointed out the similarities between transportation and the utilities, the feasibility report concluded that the procedures used in the utilities could not be directly adapted to transportation planning. Four specific differences were highlighted in the feasibility report. These are summarized in Table 1.

Table 1.1: Key Differences Between Electric Utilities and Transportation

Issue	Electric Utilities	Transportation
Consumer Satisfaction	Maintained or improved. Service goals are usually achieved.	May change in either direction. Time, flexibility, and other characteristics of the service are affected by the policies chosen.
Service Quality	Amount of electricity used is seldom affected by service quality (e.g., "brown-outs") for residential users. Goal is for quality to be independent of usage.	Quality of service is an integral part of the planning process. Changes in quality affect usage.
Project v. Modal System	Most supply and demand options are largely independent of each other (e.g., an insulation program does not affect costs or benefits of most other options).	Each segment of the modal system affects other segments (e.g., eliminating a bottleneck at one point may create bottlenecks elsewhere in the system).
Level of Service	Expected to provide all electricity demanded at prevailing price in most circumstances.	Funding level determines the amount of service provided. Projects compete for budget. Some DSM options may raise revenue.

First, the level of consumer satisfaction with the method of service provided is more of an issue in transportation than in the provision of electricity. Most least-cost options in the utility industry, especially those relating to non-business consumers, do not change the level of service that the customer receives, they just change the amount of electricity used in achieving the customer's service goals. For example, customers typically do not care whether the comfort level in homes is achieved by generating more electricity, by improving home insulation, or by using more efficient heaters and air conditioners. Transportation, especially personal transportation, involves many characteristics that customers do value, such as flexibility, comfort, and time. Hence, evaluation techniques must be sensitive to customer satisfaction with the method of service provision.

Second, use of the transportation system is affected by the quality of the service provided. Delays caused by congestion of roads or mass transit systems may cause changes in travel patterns. Reducing these delays then may increase the number of people using the system. These changes in the quality of service are less likely to occur because of choices made regarding provision of electricity. The evaluation techniques must be sensitive to potential users of the transportation system, or those diverted from using it because of service quality.

Third, each transportation mode has system or network characteristics that make it less feasible to treat parts of the system in isolation. These network components are not of great importance in evaluating electricity generation or consumption, but they are in evaluating transportation. In particular, some demand management options that might be considered at the mode level are largely precluded if the analysis is done at the project level. For example, Oregon is currently considering the effect of land-use decisions on the transportation system and vice versa. However, certain options relating to land use, such as increased density, may not be effectively evaluated as alternatives to specific road improvements. Increased density in a particular area is likely to increase the demand for road capacity in that area even if it reduces the demand overall. Hence, evaluating the land-use option relative to a specific road improvement option may generate different conclusions than comparing the options at a more aggregate level.

Fourth, electricity planning is done with the expectation that all of the electricity required will in fact be provided. In transportation planning, different levels of service associated with different funding levels are routinely analyzed. Also, because many transportation demand management options raise revenue, the impact of changes in revenue must be considered.

The feasibility report identified several issues as important in any attempt to implement the least-cost approach. The first is the identification of objectives. A benefit of the technique for utility planning is the clear objective to either generate electricity or reduce the demand for electricity. The objective for transportation planning is not so readily identified, and there are likely to be multiple objectives that must be considered. For example, enhancing mobility is a conceptually clear objective for transportation, but there are no obvious ways to measure this objective for planning purposes. Alternatively, reducing vehicle miles traveled (VMT) is a clear objective, but it does not fully reflect the service provided to transportation users. Many policies that reduce VMT may make users of the transportation system worse off.

The second important issue was to determine the procedure by which each option would be evaluated. The major benefit of the least-cost planning technique is to provide a mechanism for comparing disparate solutions.

Finally, the cost of the analysis itself must be considered. The complications in the evaluation, given the differences between transportation and electricity, could substantially affect the cost of the analysis. The high potential cost means that there must be a careful evaluation of the complexity of the analysis that will be done. Budget constraints mean that a trade-off is likely to be faced between a systematic application of low-cost evaluation to a wide range of options, versus limited application of more costly evaluation techniques. Further, all analysis is subject to uncertainty, and some evaluation of the likely gains from additional analysis is important.

1.2 DEFINING LEAST-COST TRANSPORTATION PLANNING

Since there is no accepted definition of least-cost transportation planning, we will attempt to specify the characteristics that appear to be important in any attempt to implement the approach. There is even controversy about the appropriate terminology, with terms such as "integrated resource planning," and "integrated transportation planning" suggested as possibilities. For simplicity, we will retain the term "least-cost planning," and try to identify the principles and characteristics that people seem to have in mind when using this terminology. These are summarized in Figure 1 and discussed below.

Table 1.2: Characteristics of Least-Cost Transportation Planning

A. Focus on Efficiency in Meeting Transportation Objectives
- Related to cost-benefit or cost-effectiveness analysis
- Expands the range of options considered
- Requires analysis of existing laws and standards

B. Requires Fair Consideration of All Costs
- External costs
- Time, comfort and convenience of travelers
- Based on careful analysis

C. Realistic Appraisal of Likely Outcomes
- "Do nothing" will cause people to adjust behavior - must be considered
- Long run changes in location & travel behavior must be considered

D. Planning Process Must Incorporate Uncertainty
- More emphasis on flexibility in responding to changing demand
- More analysis of project impacts under varying demand options
- Consideration of possible major changes in technology or policy

E. Common Evaluation for Objective Comparison of Diverse Alternatives
- Flexible approach needed
- Must balance cost of evaluation against improved decision-making

First, least-cost planning, as the name implies, puts greater focus on reducing the overall cost of the transportation system. Much of the discussion of least-cost planning in both the utilities and in transportation is related to cost-benefit or cost-effectiveness analysis, and these evaluation techniques are focused on efficient use of resources. The biggest change from the current approach to transportation planning is to put greater focus on demand management, but the efficiency focus also raises questions about how capacity improvements are evaluated. In particular, standards specified in terms of level of service requirements may preclude a large range of both supply and demand options from consideration. Hence, least-cost planning should allow for an evaluation of the costs and benefits of such standards.

Second, least-cost planning must be done in light of the full cost of each option. This requires some realistic evaluation of all costs, including traveler time costs, externalities, and so on. While such evaluations will include many costs not typically evaluated currently, they should not rely on unfounded assertions regarding the true cost of each option.

Third, the technique requires realistic appraisal of the likely outcome associated with each option being considered, including a do-nothing option. Such evaluations must take account of the changes in behavior typically found with substantial changes in transportation system characteristics. These include changes in location or travel behavior in response to improvement or deterioration in service and/or cost.

Fourth, uncertainty must be acknowledged and incorporated into the planning process. In the utilities, this has led to a greater emphasis on the need for flexibility in planning to allow quicker response to a wide range of possible outcomes; however, in transportation, it does not appear to be common to consider a range of possible outcomes nor varying responses to outcomes in the potential range.

Fifth, a common evaluation technique must be used that makes fair comparisons across widely divergent approaches to transportation requirements. Elements of cost-benefit analysis will be an important part of the evaluation technique, but cost of evaluation and ability to make comparisons may lead to a variety of screening options.

1.3 DOCUMENTATION

The study team, project manager, and Technical Advisory Committee (TAC) selected a section of US Highway 26 - hereafter referred to as the Mt. Hood corridor from Rhododendron to State Highway 35 - to conduct an evaluation of the transportation planning process to identify ways in which least-cost planning principles might be incorporated. This work was done in several stages. The first was a documentation of the planning process used for the project. The second was an attempt to identify specific points in the process where least-cost planning principles might be relevant. The third was to indicate the data and methods of analysis that might be used in a least-cost planning process.

Prior to selection, the project manager and the TAC determined that the case study project should satisfy as many of the following criteria as possible:

- It should involve potentially significant land-use and environmental impacts.
- A broad range of demand-side alternatives should be involved.
- The planning process should be advanced to the point where additional data collection efforts are minimized.
- To the greatest extent possible, the project should be capable of illustrating the contrast between the present planning process and least-cost planning approaches.
- The project should exhibit impacts at the system level.
- The project should be located in an urban area.

After consideration of a number of possible projects, the study team in consultation with the project manager and advisory committee selected the Mt. Hood corridor study. While the project is not in an urban setting and its system impacts are fairly limited, the Mt. Hood corridor does meet all of the other criteria.

The project chosen was not constrained to be representative of the typical corridor planning process. Rather, it was chosen to examine how the planning process worked in a specific instance. Further, some aspects of the planning process associated with this project appeared to be closer to least-cost planning principles than the typical process. This offered an opportunity to evaluate the effectiveness of an attempt to broaden the issues usually considered in corridor planning.

2.0 THE MT. HOOD CORRIDOR CASE STUDY PROCESS

The first step in the case study of the Mt. Hood corridor project was the documentation of the transportation planning process. The purpose of this effort was to review actual planning practices and to determine how the application of a least-cost planning process might alter these practices. This information could then be used to explore how the transportation planning process might be modified when using least-cost planning methodology.

Located within the Mt. Hood National Forest, the project extends along US Highway 26 from Rhododendron to the junction of State Highway 35. It contains multiple highway segments of two, three or four lanes. As part of US 26, it is a designated Access Oregon Highway. This designation has the specific requirement that the facility provide "maximum levels of service at the highest safe operating speeds possible (recommended 55 mph for rural highways) with minimum amounts of delay in transporting goods and people between major economic centers and the interstate system" (ODOT, 1991: C1- C4). This highway was determined to be deficient due to significant congestion, primarily on weekends during the winter and summer months, and due to a high accident rate (ODOT, 1981; USDOT, 1995). The corridor is within Region 1 of the Oregon Department of Transportation (ODOT), and Region 1 representatives had responsibility for conducting the study.

2.1 HISTORY

Over 20 years has passed since a study for this part of US 26 identified congestion and safety as major issues (ODOT, 1981). ODOT's previous strategy was to address problems as funds became available, working its way up the mountain "segment by segment." Region 1 planners revisited the corridor after a group of skiers appealed directly to the Oregon Transportation Commission in 1992 to address the congestion issue (Kaiser, 1995).

In response to this request, but confronted with uncertainty about future funding, Region 1 designed a process that would "ensure the best general direction for transportation management in the corridor for the next 20 years" through the development and evaluation of "a range of alternatives which respond to existing and projected problems both in a variety of ways and in varying degrees" (Kaiser, 1995; USDOT, 1995). In addition, it was the stated purpose of the study to "look for a balanced mix of capacity improvements, alternatives to single occupancy vehicles, and land use policies" (USDOT, 1995).

To accomplish this, Region 1 sought to implement a process different from previous corridor studies ("to step out of the box"); one which was encouraged by the mandate of the Intermodal Surface Transportation Efficiency Act (ISTEA) and one which reflected the direction that ODOT was going with new corridor studies (Kaiser, 1995). Key features of this process included hiring an outside consulting firm to participate in identifying, screening and assessing options; designing a public consultation process "to give everyone fair and impartial participation in the plan;" and linking the planning process with a Tier 1 environmental impact statement process in order to develop a comprehensive approach to the corridor. It was this latter component which made the Mt. Hood corridor study distinctive from other corridor studies (Kaiser, 1995).

The recommendations from corridor studies may or may not be implemented. If recommendations are implemented, however, there is usually a separate project for each portion/segment of the corridor. Each project is open to challenges from intervenors. For example, when a project falls under the National Environmental Policy Act (NEPA), intervenors can tie up or halt the project under this review. Blocking an activity in one segment of the corridor would essentially block the implementation of the whole plan.

Since it might take many years to complete the recommended improvements in the Mt. Hood corridor, and because a wide range of interests were affected by the development of US 26, conflict appeared likely. However, FHWA permitted Environmental Impact Statements (EIS's) to be undertaken at the conceptual level (Tier 1). Linking the corridor study with a Tier 1 EIS would reduce the opportunity for conflict by bringing general agreement over a set (package) of acceptable alternatives for the highway which could not then be challenged when individual projects for specific segments were implemented. At this stage, only the specific design components could be challenged under the NEPA process. Region 1 representatives argued successfully for this addition to the Mt. Hood corridor study (Kaiser, 1995).

The U.S. Department of Transportation and the Oregon Department of Transportation were designated as the lead agencies, with the U.S. Department of Agriculture, the U.S. Forest Service, the U.S. Army Corps of Engineers, and Clackamas County as cooperating agencies.

2.2 THE EIS PROCESS

Figure 1 portrays the major stages of the Mt. Hood corridor Tier 1 EIS process. In addition to public hearings and open houses, public input to the planning process was generated through two citizen committees. The thirteen member Citizens Advisory Committee (CAC) represented broad-based interests from the community, including automobile users, bus companies, mountain recreation users, the trucking industry, the resort industry, land-use interest groups, small business, local communities, summer home owners, the tourism industry and environmental groups.

The Technical Advisory Committee (TAC) contained key members from local, state and federal agencies including the U.S. Forest Service, Clackamas County, Oregon Department of Transportation, the State Historic Preservation Office, the U.S. Fish and Wildlife Service, the Department of Land Conservation and Development, the Confederated Tribes of Warm Springs, the Confederated Tribes of Grand Ronde, the Division of State Lands, the Department of Environmental Quality, Tri-Met, Oregon Department of Fish and Wildlife, the Environmental

Protection Agency, the Federal Highway Administration, the Oregon Bicycle Advisory Committee, Hoodland Fire District #74, and two liaison members from the CAC. The purposes of both of these committees was to advise ODOT and FHWA.

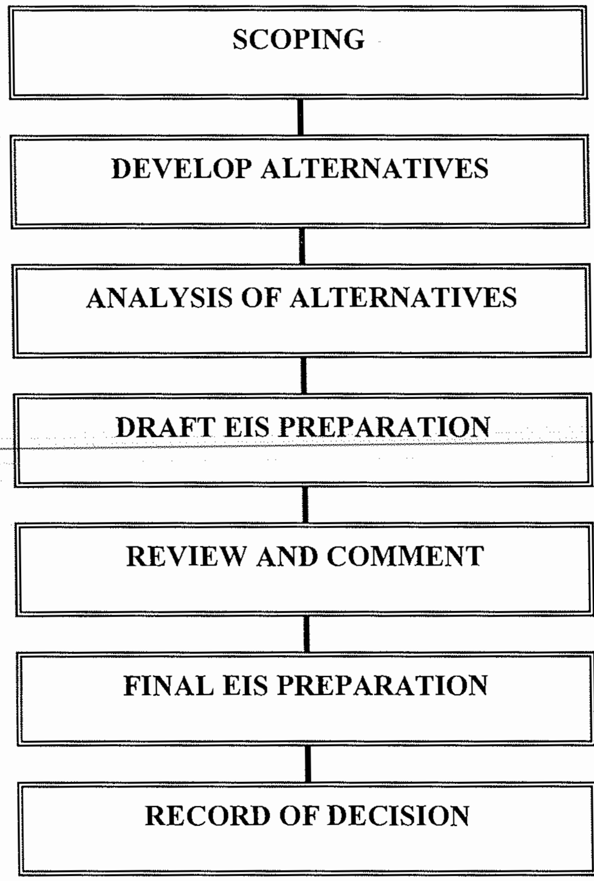


Figure 2.1
Major Stages of the IS Process

After an initial scoping phase, a list of alternatives was developed by the consultants for presentation to the Citizens Advisory Committee and the Technical Advisory Committee. The responsibility of each of these committees was to review the alternatives, add new options, and ultimately to recommend which alternatives should move forward for the public hearing. During this time, the consultants, with input from ODOT analysts and a variety of subcontractors, analyzed the impacts of the proposed options. A preliminary Draft EIS (USDOT, 1994) was prepared and reviewed by ODOT, FHWA and the cooperating agencies, after which a Draft EIS (USDOT, 1995) was prepared and published.

Each designated cooperating agency must formally sign off on a Draft EIS. Once the agencies accept the Draft EIS, hearings are scheduled. Based on public testimony and decisions at the hearings, a final decision will be made by ODOT, and again the cooperating agencies must sign off on the content of the corridor plan.

It is important to note that at the time of this report, the public hearing on the Draft EIS had yet to occur. Nevertheless, it is still fruitful to explore the methods and procedures for identifying and screening options for final review. These methods and procedures will be evaluated relative to the principles of least-cost planning as they might conceivably be applied to transportation planning. The analysis should not be construed as a critique of the Mt. Hood corridor study process. The Mt. Hood corridor study process is constrained by legal requirements as to how the process occurs and issues that should be addressed. Part of the least-cost planning process is to identify when such requirements prevent certain options from being fully evaluated.

2.3 SCOPING

Scoping sets the parameters of the study by defining which "alternatives, issues and impacts are to be studied" (CAC, 1994b). Scoping was accomplished through consultation with ODOT, cooperating agencies, the Federal Highway Administration, through consideration of relevant laws and regulations, and the perceived interests of the public (Lee, 1995).

From the inception of the preparation of the Mt. Hood Corridor Draft EIS, Region 1 planners were committed to a review of transportation system management (TSM) and transportation demand management (TDM) options along with construction options (Kaiser, 1995). In addition to the legal mandates calling for consideration of TSM/TDM alternatives, concern over cost, environmental impact, historic sites, and other potential problems argued for considering alternatives to construction. In addition, ODOT took a restricted view toward analyzing land/economic development impacts. The scope of the study was to include the needs resulting from existing or approved development but not the needs which might result from new development activities. (Kaiser, 1994).

The scope of the project is formally defined in the public notification of the Tier 1 EIS in the Federal Register. This document outlines a broad range of options to be reviewed including TDM and TSM, construction, maintenance and operation; and it sets the parameters for environmental, economic and social review. Following this notification, consultants were hired to identify and analyze alternatives and were given instructions "to consider as broad a range as possible"..."the sky's the limit" (Kaiser, 1995).

A number of legal mandates both expanded and restricted the scope of options. These mandates include

- The Intermodal Surface Transportation Efficiency Act (ISTEA)
- The Oregon Transportation Plan (OTP)
- The Access Oregon Highways Program
- The National Environmental Policy Act (NEPA)

ISTEA and the Oregon Transportation Plan expanded the scope to include demand-side and transportation system management, as well as requiring the consideration of land-use impacts. The Access Oregon Highways program sets level of service standards that are unlikely to be met without construction. For example, the expectation is that Access Oregon Highways will allow speeds of 55 mph in most circumstances.

NEPA expanded the analysis to include a broad range of environmental, social and economic issues which in routine corridor studies would never be reviewed (Edrington, 1993). Further, it required that a no-build option be analyzed. On the other hand, NEPA also restricted the analysis to activity within the corridor and to options that can be implemented at this time (Lee, 1994).

During the screening process, a number of alternatives were excluded because they were beyond the defined scope of the study. For example, an alternative diverting truck traffic away from US 26 was excluded because it would require actions (upgrading of other highways) and analysis of impacts beyond the corridor (Lee, 1994). In addition, a toll road or congestion pricing were eliminated because neither is permitted on a federally funded highway. The decision was made to discuss in the Draft EIS why congestion pricing was eliminated and to explain that it might still be an option if there were a change in legislation or conditions on the road (Kaiser, 1995). Finally, NEPA requirements refocused the analysis from a more general planning document to an action document for the corridor, one which required the specification of the relationship between options and capacity needs (Robinson, 1994).

2.4 NEED FOR THE STUDY

The Mt. Hood corridor Draft EIS documented "needs" for action under NEPA are based on performance and capacity deficiencies. The four problem areas identified are:

1. Peak congestion
2. Level of service
3. Safety
4. Road design deficiencies

Deficiencies were determined by the standards established for an Access Oregon Highway and by ODOT safety experience on rural high-speed highways (USDOT, 1995). These standards called for a management objective which is to provide "safe and efficient high-speed (55 mph), continuous-flow operations..." The Mt. Hood corridor was defined as deficient in the Draft EIS because:

- summer and winter weekend traffic flow in the corridor experienced slow to moderate speeds with interruptions in flow;
- US 26 in the corridor has numerous deficiencies, based on current highway design;
- traffic volumes in the corridor either approach or exceed capacity during peak summer and winter periods. The volumes also exceed the minimum tolerable conditions listed in the 1991 Oregon Highway Plan for a statewide, rural highway in mountainous terrain;
- future travel demand in the corridor will exceed the existing capacity of US 26 for extended periods of time during summer and winter weekend days;
- the existing accident rate in the corridor is two times higher than accident rates for other primary rural, non-freeway highways.

The Access Oregon Highways standards provided justification for action. Drawing on American Association of State Highway and Transportation Officials (AASHTO) guidelines, the level of service (LOS) standard dictated by the Access Oregon specification was modified because of some site-specific characteristics of the road, (e.g., frequency of snow conditions as well as the relationship of some congestion to down-hill skiing activities). To address these specific characteristics, the 100th highest volume (HV) hour was chosen to evaluate the service standard rather than the routine 30th HV. The selection came after discussion of the merits of two alternatives: 1) 30th HV and 2) the traffic volume which represent 50% of the highest volume (USDOT, 1995: Appendix B).

While the study indicates that an effort was made to analyze who was using the highway for what purposes, there is little documented discussion that considers the definition of need (or problems) from the perspective of the variety of different users. (Some of these discussions appeared to have occurred in the CAC and TAC meetings, but do not appear in the Draft EIS). That there are diverse needs is suggested by data on recreation visitor days (USDOT, 1995: Section 3, 3-13) which lists 22 different recreational uses, the greatest of which is "driving for pleasure." Internally, ODOT did address the needs of the ski industry and developers on the mountain by taking the position that these groups should "collectively (be) seeking ways to meet development objectives without adding to existing highway capacity problems" (Kaiser, 1994). Again, this perspective is not addressed directly in the Draft EIS.

2.5 FORECASTING

To forecast traffic volume in the year 2015, analysts relied on a simple projection of recent traffic growth in the Mt. Hood corridor. Two forecasts were generated, reflecting 2.6 % and 3.1% annual growth in traffic volume. The lower rate is assumed to be a minimum and is loosely associated with the no-build option, while the higher rate is asserted to be a maximum reflecting the trip generation effects of capacity improvements. While planned development within the corridor is reviewed, developments outside of the corridor that might affect demand, with the exception of population growth, were identified but not analyzed (UDOT, 1995: Section 4).

2.6 PROCESS FOR SCREENING OPTIONS

The Mt. Hood corridor Draft EIS identifies four alternatives. The no-build option is required by law. Each of the three build alternatives has four design options. All of the alternatives include maintenance and enforcement options. The three build alternatives all include a moderate TDM program.

> ***Alternative 1 (no build)*** Includes improved maintenance (upgrade to Class A), increased traffic enforcement and enhanced operations (e.g., an advanced traveler information system (ATIS)).
>
> ***Alternative 2*** Widen all two-lane segments to three lanes and all three-lane segments to four lanes through the section known as the Laurel Hill curves; operate a moderate TDM program (parking and transit); and enhance operations, maintenance and enforcement (same as Alternative 1).

Alternative 3 Between Rhododendron and the top of Laurel Hill, improvements would be identical to Alternative 1; from Laurel Hill to OR 35 junction, widen to five lanes; TDM, maintenance, operations, and enforcement same as Alternative 2.

Alternative 4 Widen all segments of corridor to four lanes with an additional turn lane where appropriate; TDM, Maintenance, operations and enforcement same as Alternative 3.

The three build options each have four design options: a low cantilever wall; a tall wall; a sidehill bridge; and a terraced slope. The design options primarily affect the visual impact of new construction, and they vary substantially in cost.

The process that generated the four alternatives was iterative and relied on both qualitative and quantitative analysis. As defined by the consultants, the process involved three stages:

1. Practical
2. Pairing
3. Level of service screening

Initially, a list of options was developed by the consultants in consultation with ODOT to present to the CAC and TAC. This list included:

- Seven major capacity improvements
- Five operation/safety improvements
- Ten travel demand management options
- Three maintenance options
- Four enforcement options (See Appendix A)

At this point some options were eliminated and others were added by the CAC and the TAC.

As documented in the Draft EIS, a broad range of criteria were applied to screen options. These criteria included:

- Level of service effects
- Environmental impacts
- Visual impacts
- Technical difficulties
- Obvious costliness
- Safety issues
- Legal requirements
- Agency interests

For example, a rail alternative was eliminated because there was no existing corridor, and it was perceived that the impacts would be too great (USDOT, 1995: 2-3). The five safety improvements were eliminated as stand-alone alternatives because they "did not address capacity-related problems" (USDOT, 1995: 2-3). The Still Creek option, which would have required developing a route parallel to US 26, was eliminated because of adverse environmental and visual impacts; and a bicycle/pedestrian option (which would eliminate cars from the highway) was dropped because it was "not capable of addressing capacity-related problems."

The consultants then paired 17 options (build, maintenance, operations, and enforcement) with two performance objectives, LOS and user management (trip reduction), and asked for CAC review. Viable options were identified based on ability either to meet LOS or reduce trips. For example, the expectation for LOS was broken into three categories: no improvement, maintain existing operating conditions, and improve to LOS C. User management was broken into no improvement, moderate (5-15%) reduction in trips, and significant management (more than 15% reduction in trips). (See Appendix A)

As result of this process, and further screening using the criteria of whether an option is required in the Draft EIS, corrects safety deficiencies, or meets LOS performance objectives, the consultants eliminated several build alternatives, operational alternatives and transportation demand management as stand alone options (CAC, 1994a).

Further refinement eliminated congestion pricing. Finally, the four design alternatives for each of the build options are included in the Draft EIS. The addition of the design alternatives occurs after a request from the U.S. Forest Service, in a May 4, 1994 letter to Theresa Lee, for a fifth build alternative which would include design options which are visually appropriate for a highway that is the "front door for the Mount Hood National Forest" (USFS, 1994). The alternatives were then analyzed according to their impact on LOS, as well as to their social, economic, environmental, cultural and aesthetic impacts, and the findings published in the Draft EIS.

As noted, a variety of criteria are applied throughout the screening process; however, the criterion which is given the most weight is the ability to address LOS deficiencies. Maintenance, enforcement, operational and moderate TDM options are excluded as stand-alone alternatives because none could address the LOS deficiencies. As documented in the Draft EIS, only build alternatives can address LOS deficiencies.

While the costs of the options are published in the Draft EIS, there is no evidence that cost was used as a screening criteria, except in the case of the rail option (in which it was argued that the cost would outweigh the benefits). On the other hand, the inclusion of the TDM options as well as maintenance, operational, and enforcement options with each of the build alternatives is not typical of more recent corridor studies in other areas. Table 3 presents the cost of different design options for the three build alternatives.

The Mt. Hood corridor study contains more consideration of alternatives, such as demand management, than is typical for such studies. While this project did not encompass a detailed review of the corridor planning process, a brief review of a draft Overview of Statewide Corridors (ODOT, 1995) provides some indication of the type of analysis typically done for corridor studies. In this analysis, there is consideration of safety, design, and level of service deficiencies and the cost of improvements to offset these deficiencies. The studies refer to "high management" and "low management" options, but these do not relate to analysis of TDM or other traffic management options. Rather, they relate to an assumption regarding changes in land use, with low management implying expected changes in land use while high management is somehow expected to include prevention of changes in land use. Little information is provided regarding the feasibility or cost of these options.

The analysis does consider various items labeled as "cost effectiveness," with the analysis of cost effectiveness of achieving travel time reductions coming closest to the type of information that might be useful in a least-cost analysis. However, this information relates only the cost of various capacity improvements to expected reductions in travel time, and it does not appear to be capable of incorporating the cost and effectiveness of alternatives to construction.

Table 2.3 Estimated Costs of Mt. Hood Corridor Project Options (Thousands of 1994 Dollars)

Option		Cost
Operations/enforcement		$450
TDM (Transit)		4,450
Alternative 2	Cantilever Wall	57,400
	Tall Wall	74,300
	Sidehill Bridge	115,850
	Terraced Slope	157,500
Alternative 3	Cantilever Wall	71,500
	Tall Wall	83,250
	Sidehill Bridge	127,500
	Terraced Slope	169,250
Alternative 4	Cantilever Wall	74,250
	Tall Wall	86,250
	Sidehill Bridge	130,500
	Terraced Slope	172,250

Source: USDOT (1995)

2.7 DATA

The Mt. Hood corridor Draft EIS relies on data, guidelines and standards contained in the *US Highway Capacity Manual* (HCM) (Transportation Research Board, 1985), the U.S. Department of Transportation's 1989 *Annual Report on Highway Safety Improvements* and AASHTO guidelines. In addition, National Highway System design standards (although US 26 is not yet designated as part of the National Highway system) were used for assessing deficiencies and designing build alternatives. This was supplemented with information from other ski areas. Additional surveys of traffic in the corridor were conducted as well as a variety of independent analyses of the environmental, social/economic, and cultural impacts of various alternatives.

Analysis was done for discrete problems. In some instances, quantitative modeling techniques (e.g., traffic volume estimates) and in others qualitative assessment of a strategy based on experience of its use in other situations were used. Much of the analysis of TDM measures was qualitative.

For hourly traffic volumes, the study relies on ODOT data obtained from a traffic monitor on the mountain. A monthly traffic report provides average daily volume and east/west flow. This information is supplemented with data on origin and destination within or outside of the corridor obtained from observation and a previous survey of skiers at resorts. In addition, a video of traffic flows from February 1993 until Spring 1994 was analyzed to determine the relationship between traffic flow and weather conditions (Carlson, 1994).

Safety was addressed by data on time, weather condition, type of accident, location and rate of accidents in the corridor for the years 1989-1991. This was assessed using the Safety Priority Index. Estimates of increased safety resulting from each alternative relies on experience on other Oregon highways with increases in capacity and improved maintenance, operation and enforcement.

To assess congestion pricing, the consultants relied on their experience and a few studies which are extant. Additional data covered characteristics of the roadway (e.g., curves, alignments etc.), road sanding volumes, access points to the corridor, population statistics, as well as experience of other ski resorts with TDM or build options (e.g., trains, hooded highways). The study also includes a variety of qualitative and quantitative data that address the environmental, socio-economic, cultural, visual, and geologic impacts of the build alternatives on the study area.

2.8 PUBLIC INVOLVEMENT

Involving the community and the public in the process was a goal of the study team (Mt. Hood Corridor Study Newsletter, 1994). More importantly, Region 1 planners wanted to insure that everyone had an opportunity for fair and impartial participation (Kaiser, 1995). The process for public involvement included several components. First, the team conducted a survey of community members about their interests with respect to development of the Mt. Hood corridor. These discussions were also used to identify candidates for participation on the Citizen's Advisory Committee. The groups contacted included business and community groups; environmental and preservationist groups; bicycle, trucking, transit, tourism/recreation, and resort/ski industries; and land-use planning groups. In addition, the team held two open houses early in the process, published a newsletter on the study and provided materials at several information centers.

The heart of the public involvement process, however, was the participation of the Citizen's Advisory Committee and the Technical Advisory Committee in the screening process. A total of six meetings were held with each group during the winter and spring of 1994. The CAC meetings were held first to underline the importance of the citizen's perspective. In addition, two representatives from the CAC also attended the TAC meetings. The two groups acted in an advisory capacity. Final decisions, however, were made by ODOT.

A diverse set of interests were represented at these meetings and a variety of issues were raised including questions as to need, purpose, strategy and impacts. Responses to the questions reflect the importance of the legal and institutional mandates in defining the scope and structuring the analysis to address LOS deficiencies (e.g., Access Oregon mandate).

Most important for this study, however, is the observation that the documented screening process indicates that the primary way to analyze the relative merit of different options was in isolation and against a level of service standard.

2.9 DOCUMENTATION

In addition to defining the scope and analysis of the corridor study, the EIS process structures how information will be presented in the document. The document must discuss purpose and need, review alternatives and then discuss the various impacts of these alternatives on the environment, the economy, society, land use, and so on. Purpose and need must be well defined and related to existing deficiencies. Only alternatives which can be implemented within the corridor may be analyzed. Further, NEPA requires analysis and documentation of the impacts of a no-build alternative. The implication is that the choice is between no highway construction or some highway construction, even though all alternatives included additional no-build activities (e.g., maintenance, operations, TDM).

It was the intention of the study team to define an array of options that could be implemented in the corridor over the next 20 years based on need; however, the final focus on build options leaves it unclear as to whether this is feasible or not. This may simply reflect the EIS process, but it does leave the impression that the process resulted in the elimination of the non-construction options as interim alternatives.

2.10 LESSONS

No plan can address the complete range of possibilities, and the Mt. Hood corridor study is in many ways unique. However, the analysis does serve to highlight several important differences between a planning approach based on least-cost principles and the planning process currently used. These differences are summarized in Table 3.

First, the level of service standard specified by the Access Oregon Highway designation is inconsistent with a generalized least-cost planning approach. By specifying the level of service as a requirement, actions that can not achieve this level of service are not acceptable, even if they can achieve substantial improvement at relatively low cost. In the utilities, the achievement of a uniform service level is an expected part of the planning process; but in transportation, funding constraints make it impossible to achieve desired levels of service for all roads simultaneously. Hence, setting a minimum service level and focusing on problem areas favors an "all-or-nothing" approach rather than allowing for some trade-off of lesser improvements among a variety of projects.

Table 2.4: Lessons From Mt. Hood

- Level of service standards may conflict with least-cost principles
- Better analysis of no-build option is needed
- More consideration of flexibility and contingent options might improve the planning process
- Wider array of alternatives should be evaluated
- Identify barriers to evaluating cost-effective alternatives
- More attention should be paid to the nature of travel demand and methods to accommodate specific requirements

The approach used in the utilities does indeed take a fixed level of service as a goal. Demand-side options are evaluated relative to being able to meet this goal. If all roads must meet a specific level of service, then least-cost planning could be used to determine the cost effectiveness of non-build options. However, as argued in the feasibility report, least-cost planning in transportation must frequently allow for some trade-off of service improvement and cost. **By specifying the level of service in advance, the Mt. Hood corridor planning process effectively precluded a balancing of the cost and service improvements associated with demand management. Since they could not achieve the target service level, they were not included as stand-alone options.** This is appropriate only if there is a compelling reason to set such rigid service standards. Where such standards are appropriate, then an approach more similar to that in the utilities is appropriate, where each option is evaluated in terms of cost-effectiveness in achieving the desired service level.

Hence, the first lesson is that a greater variety of service levels ought to be considered in the planning process. To the extent that they are not, the process will tend to favor construction options. A least-cost planning approach should allow some evaluation of the trade-offs between costs and service improvements associated with various approaches. In this circumstance, the relatively small contributions to service improvements of some demand-side options are viewed more favorably because of their relatively low cost. This is of particular concern where budget constraints will not allow large outlays.

Second, the analysis should explicitly recognize the interaction between service improvements and travel demand. The no-build option in the Mt. Hood corridor study essentially assumed a continuation of recent growth in traffic. However, it is reasonable to expect that traffic volume will be affected by the actions taken. Certainly, more people will want to use a highway that allows for 55 mph travel than will want to use one that is severely congested, but a variety of changes in travel patterns and land use are possible. The impact that changes in service will have on usage should be considered in the planning process. This is particularly important over long periods when travel patterns, land use, and technology could all change substantially.

Third, the least-cost planning process emphasizes flexibility. The process used for the Mt. Hood corridor appears to be very deterministic. While there is likely to be more flexibility in implementation than there appears to be in the set of options considered, the very nature of the process does not allow for the consideration of contingent options. For example, it might be possible to do some preliminary work, such as right-of-way acquisition, that would allow for more rapid construction at some future time if traffic volume increased at a faster-than-expected rate, but to proceed with demand management options for the immediate future. Essentially there is no matching of the timing of increases in demand for service and the timing of the provision of the increased capacity or implementation of demand management options.

Fourth, a least-cost planning process would consider a wider range of alternatives. For example, the possibility of providing parking at Rhododendron and shuttle service to the ski resorts does not seem to have been carefully evaluated. While it may not be feasible under current conditions, alternatives such as higher parking prices at the resorts may make it more feasible. In general, methods to improve viability of demand-side management options did not appear to get as much consideration as they would in a least-cost process.

Fifth, the nature of the travel and the possibilities of diversion to or from other routes should be considered more systematically. Particularly if the peaking problem is associated with recreational usage, analysis of the other types of traffic on the road and their alternatives should be considered. It may be that high priority usage for other activities could be met on other routes, and this may then make it more feasible to accommodate recreational travel without additional construction.

While some of the issues raised in the case study are specific to the EIS process, it does appear that least-cost planning principles would lead to some differences in the transportation planning process.

2.11 HIGH LEVEL ANALYSIS

Transportation planning can be done in a variety of ways, but conceptually we can specify three different levels. The highest level is the consideration of the entire transportation system and its relationship to other systems, such as land use. At this level, broad questions such as the most efficient modes to service various types of transportation demand can be addressed. In Oregon this corresponds most closely with the plan element and to some extent the system element of the Oregon Transportation Plan, but it also encompasses laws and other policies that affect the viable range of options for transportation. The next level takes broad policy issues as settled and looks at methods to meet these objectives within a fairly large scale. The second level analysis will typically be done with restrictions and directions specified at the higher level influencing choices. In Oregon, this most closely fits the type of planning done at the corridor or metropolitan planning organization level. Finally, the lowest level of transportation planning corresponds to individual projects, where small amounts of the system are considered in great detail.

The Mt. Hood corridor is an integral part of the state highway system. US 26 provides important access to central Oregon from the Portland metropolitan area. Further, it provides access to recreational opportunities, and it provides local access for residents. Other uses have also been identified. A high-level analysis should be made as to how the various goals for both this highway and other parts of the transportation system can be met. The existing process must address a variety of goals as set forth in various federal and state documents. This process sets constraints on the planning that occurs at lower levels. Least-cost planning would follow a similar procedure, but it would place more emphasis on the evaluation of efficiency issues at the highest level of planning. It would also incorporate some evaluation of the impact of various legal restrictions as they relate to transportation efficiency.

High-level analysis examines the trade-offs between various modes in meeting transportation planning objectives. It is also at this level that interaction among modes is primarily addressed. Yet it would be a mistake to consider this analysis as being independent of lower-level analysis. For example, high-level analysis should be predicated on some estimate of the cost of putting the components of the system together, but these cost estimates can only come from more detailed plans. Hence, there is some implied interaction between the different levels of analysis. Yet in practice, guidelines must be specified from higher levels to be incorporated into the analysis at lower levels, and there appears to be little opportunity for information associated with implementation costs to be used in refining higher-level analysis. Least-cost principles argue that these guidelines at least offer some flexibility in meeting objectives when cost is greater or benefits are lower than anticipated.

The Mt. Hood corridor illustrates these issues. The Access Oregon Highway designation is a high level decision. This decision is based on certain objectives for the state highway system. A least-cost approach would start with a careful evaluation of the costs and benefits of the Access Oregon Highway (AOH) designation, especially the characterization of minimum service levels and other characteristics. One key feature of the AOH program is the set of system attributes as well as the prioritization implied by the designation. Uniformity and connectivity are important in evaluating a transportation system, but the specific characteristics that come out of a least-cost approach may differ from those specified in the AOH program. While system characteristics are clearly important in higher level evaluations, there should also be guidelines for deviation from uniform criteria where costs are high or benefits are low relative to the average. Thus, the objectives specified for the AOH program could be met by meeting the service standards specified, but given the high cost of construction for this highway, more consideration of alternatives might be warranted. The key question is how to provide these incentives without sacrificing the coordination needed for the system as a whole.

We do not pretend to have a complete answer to this concern at this time, but certain characteristics of the approach appear to be identifiable. At the high level, some estimates of the cost of various approaches to meeting transportation requirements would be needed, but the large variation of cost associated with different segments of the system would also be noted. A weighting scheme of some sort would highlight the system benefits associated with various projects, but these would be weighed against costs. If the system benefits have been appropriately evaluated, the cost effective decision could be reached. If the segment is a major part of the system and cost turns out to be very different than anticipated, then it may be necessary to go back and revise the higher level plan. With the Mt. Hood corridor this might simply be associated with the consideration of cost when evaluating alternatives, but it would probably require some estimation of the benefits generated by various types of development as well.

To make this a little more concrete, the high level analysis would use modeling and system evaluation along with careful estimates of cost associated with various system approaches. These would include consideration of demand management, land use, and alternative mode methods to provide service. A general system plan would then be drafted. From this plan, an incentive system would be developed to guide lower level planning to make it consistent with the higher level plans, but these incentives would allow trade-offs based on relative costs and benefits.

At lower levels, least-cost analysis would again be oriented toward some formal evaluation of costs and benefits, but incentives would be added to experiment with demand management options. This would be necessary so that the required analysis of effectiveness for demand management and land-use options could be developed over time. As experience with these other options increases, the information can provide feedback to the higher level analysis.

Aside from the development of criteria to guide planning at lower levels, there is also the question of cost. One approach would be a full cost-benefit analysis of all options, but this would be prohibitively expensive. Rather, we recommend less formal analysis at the lower levels, since the need to fit into the system will frequently override concerns about cost for small projects. This is appropriate since it would not be worthwhile to spend more on an evaluation than would typically be saved from efficiency improvements.

3.0 EVALUATING ALTERNATIVE INVESTMENTS IN A LEAST-COST PLANNING FRAMEWORK*

This chapter examines various approaches to evaluating alternative transportation investments in the Mt. Hood corridor case study. Evaluating alternative investments requires first a set of tools for estimating what effects they will have on the transportation system and its environment. We present three approaches to evaluating transportation investments: cost-benefit analysis, what we term problem-oriented analysis, and estimation of decision-makers' preferences. Two ways of structuring the problem-oriented approach, one focused on the alternatives presented in the Draft EIS and one focused more on demand-side management options, are then illustrated.

3.1 ESTIMATING THE IMPACTS OF ALTERNATIVES

To evaluate alternative investments in a transportation system, it is necessary to have some idea of what effect each investment would have on the system. If one conducts a full-scale cost-benefit analysis, it is necessary to estimate the effects of an investment in order to estimate the investment's benefits (such as reduction in travel time). If one uses a simpler approach, it is still necessary to estimate the effects in order to make a determination of whether an investment is more effective or more attractive than another on any measure other than the cost of implementing it.

Most transportation modeling uses some variation of a four-step process. This process was designed for estimating the need for additional transportation capacity, and computer models for conducting the process are in widespread use. However, this modeling process was not designed to analyze some transportation-related problems such as air quality or energy consumption; it was also not designed to analyze transportation system changes in which substantial shifts in user behavior are desired or expected. Such changes might include measures such as congestion pricing, peak-period pricing of parking, and many demand-side management measures in which the objective is to encourage changes in how transportation system users behave.

---

* This chapter was prepared by Edward L. Hillsman and Steven R. Elliot of Oak Ridge National Laboratory. The reader is also directed to Appendix C for a discussion of two alternative methods for estimating effects on aesthetics, which have been determined to be of particular importance in the Mt. Hood corridor.

The steps in the process are:

1. Estimate trips generated at different locations (trip generation);
2. Allocate trips to destinations (spatial interaction/trip distribution);
3. Allocate trips to modes (mode-choice);
4. Distribute trips across a transportation network (assignment);
5. Possibly feedback results of fourth step to other steps to allow congestion or estimates of travel time to affect other estimates.

This process yields estimates of traffic volume on different links of a transportation system. In turn, these estimates can be used to estimate levels of service. Alternatives can be analyzed by changing the description of the transportation system, especially in steps 2 and 4, and then rerunning the process. The process can be computationally intensive, especially for a dense metropolitan transportation system. It should be considerably simpler for a system such as the Mt. Hood corridor and the alternative routes that provide service to the recreation areas within it and access between central Oregon and Portland.

The process does not handle variations in behavior well. The indicated feedback often does not occur, in which case the process does not handle the effects of congestion and capacity constraints on the propensity to make trips. If the feedback does occur, the modeling is generally performed for one or only a small number of time periods (because the amount of computation to make the estimates depends on the number of time periods analyzed) and the results of one time period are not fed back to the estimates for others.

For example, if congestion on one route is expected to be very bad between 4:30 and 5:00 P.M., step 4 of the process is good at considering whether some of the traffic might choose alternative routes, but the process is not good at considering whether some system users might change their departure times to avoid the heavy congestion, or how many might do so, or how many might leave earlier as opposed to later, or whether users may decide to forego some trips or select destinations that involve less congestion to reach. Because travelers do make these kinds of responses, if demand for transportation service is increasing, it is not reasonable to assume a simple proportional growth in travel across all time periods. Once congestion reaches a certain level during the most preferred time periods, users will begin to adjust their behaviors so that additional use will occur at less congested times or will involve less congested alternatives (in the Mt. Hood corridor, this means choosing other ski resorts or recreation areas, or other leisure activities). These are all factors that one would want to consider either in analysis of DSM or in conducting a cost-benefit analysis.

The discussion in Appendix B of the Draft EIS of choosing the "design hour" for the corridor reflects the practice of choosing a small number of time periods as the basis of the analysis. The Draft EIS notes that travel demand would probably level off if no changes are made to the corridor, (p. 4-5), but it is not clear how this assumption was incorporated into the estimates of the levels of service along different corridor segments for different alternatives (for example, in Table 4.2 of the Draft EIS).

The limited consideration of temporal variation extends across years as well as days. It is common to estimate the present state of the transportation system or corridor to prepare point estimates for a few selected future years, and to assume a simple trend in change in use between these point estimates without considering how the transition from the present system to the future one will occur. This is due to the cost of making estimates for multiple time periods and the difficulty (in method and data) in feeding back the congestion results from one period to the trip generation, mode choices, or destination choices made in the next.

The process also does not handle well some variations in user cost. Although conceptually the process can handle the effects of parking fees or tolls on some routes within a dense network, there is little empirical evidence from which to estimate variables such as the rate of change in route choice from tolls relative to congestion, or the rate of change in trip making or destination choice for different levels of parking costs or tolls. The problem of estimating these kinds of responses becomes compounded if prices are varied at different times of day or in different zones, as would occur under congestion pricing. Although the Mt. Hood corridor Draft EIS notes that tolls were not considered to be a legal option, parking fees could be feasible. In addition, nationwide there appears to be growing interest in congestion pricing; road pricing could become an option for ODOT in the future. Until more experience is gained with pricing roadways and parking, estimates of their effects probably will require Stated Preference surveys, in which system users choose among hypothetical alternatives.

Finally, because the four-step modeling process was designed as a tool for estimating the need for additional transportation capacity, it does not handle well some transportation-related problems such as air quality or energy consumption. Although these problems do not appear to be an issue in the Mt. Hood corridor analysis, air quality will need to be considered in other corridors, and energy consumption would need to be considered if Oregon were to implement initiatives to reduce emissions of greenhouse gases.

Summary. Available transportation planning tools were not designed for the purposes to which many would now like to apply them, especially for DSM and for some variables in cost-benefit analysis. Experience in using these tools for other purposes remains limited, and there is little guidance about how far the tools can be "pushed" to give the desired types of information. The need for better models is recognized, there have been calls to replace the four-step modeling process, and research has been funded to improve the existing process. However, for at least the next several years something like this process will remain the standard set of tools for analyzing transportation systems.

Application of the models in the four steps probably can best be guided using information collected in surveys of users or potential users of the transportation system. Use of the modeling process already requires information from such surveys, but the surveys will have to be structured to acquire additional types of information, such as the willingness of users to adjust their times of use or respond to changes in cost. The structure of the required surveys will depend on the framework used in comparing alternative investments, on the requirements of the specific models being used, and on the structure of any complementary surveys being administered (e.g., CVM surveys; recreational user surveys as conducted for the U.S. Forest Service and cited in the Draft EIS. See Appendix C for a detailed discussion of CVM surveys).

Using such an approach, it should be possible, at reasonable cost, to estimate a baseline "no system improvements under existing trends" state of the transportation system that reflect user adjustments to increased congestion, and to estimate how these responses would change under alternative investments. The results of such an analysis would include an estimate of the number of trips in the corridor, by hour, for days representative of different conditions and system use throughout a year, for several years. The results also would include the duration of the trips; the general purpose of the trips (travel from Portland to central Oregon; travel for major categories of recreation within the corridor; local traffic); the mode used; and the route used. These results can be used to estimate the proportion of use that occurs within different levels of the six-category level-of-service rating system now used by ODOT (Appendix A of the Draft EIS), because the level of service can be estimated from traffic volume per period of time and a description of the road system. As a rough approximation, the number of users receiving a given level of service in the six-category system can be used to estimate the time cost of using the system.

3.2 APPROACHES TO EVALUATING ALTERNATIVES

Below, we present three broad approaches to evaluating transportation system improvements, each with some variants:

- Cost-benefit analysis
- Problem oriented or cost-effectiveness analysis
- Estimation of decision-maker preferences

The remainder of the section provides a description of each of these approaches and its strengths and weaknesses. Before proceeding, it is worth drawing attention to some limitations of all of the methods discussed.

3.2.1 LIMITATIONS

All of the approaches require the ability to estimate the effects of making changes to a transportation system. As noted above, some of the effects are difficult to estimate with precision because of limited modeling approaches, limited data, or institutional limitations such as the need to screen alternatives at a preliminary stage before doing the detailed engineering work (which can greatly refine the cost estimate) for alternatives that might not pass the screen. As a result, all approaches for comparing alternatives must work with uncertain or imprecise estimates of effects. Some, as noted in a later section, must in addition work with imprecise estimates of the value of these effects.

All of the approaches may be sensitive to how the costs, impacts, and benefits of alternatives will be estimated. It is not clear that the variables that analysts can estimate or that highway engineers can measure will be what system users actually value. For example, although it can be argued that people value reduced travel time-which can be measured, estimated, and assigned a monetary value-they may place value on other benefits from system improvements that are harder to measure; a half-hour trip under congested conditions may be valued less than a shorter trip under free-flowing conditions, because of the mental cost of driving under congested conditions. Improvements in simple measures of congestion, such as the ratio of traffic volume to road capacity, may not reflect users' actual response to the improved conditions. Improvements in safety may be difficult to value if people perceive their own risk of injury as low. The sometimes uncertain links between what transportation system changes can be measured and how users value the changes is important not just for estimating the values of alternatives, but also for estimating how users will respond to changes, because their responses can determine the effects of the changes and thus what is evaluated.

In general, changes to transportation systems are not simply additive. For example, if one alternative is to increase the cost of parking for system users, and another is to widen a road, the effect of an alternative which does both is not necessarily the sum of the effects of the two components. In addition, changing the level of an alternative (such as parking fees) may have different effects in isolation than it would when implemented jointly with others. As a result, it becomes expensive and sometimes operationally difficult to evaluate the effects of large numbers of alternatives, especially when they involve bundles of simpler options. There is thus a premium on identifying a relatively small number of "good" alternatives. In addition, it is difficult to analyze and compare phased alternatives, in which the effects of early decisions influence subsequent ones. For example, one might like to examine an alternative which implements measures to manage demand and then, if necessary to maintain service, only later expands road capacity. One can estimate the effects of the demand-side management, and the effects of adding capacity in the future, but this has to be analyzed as two separate alternatives, which increases the cost of the analysis.

It is perhaps obvious, but it bears restating, that any approach for evaluating and comparing alternatives will be limited by the alternatives presented. Thus, although there is a premium on analyzing a relatively small number of alternatives, whatever approach is adopted should be coupled with a process for generating a range of alternatives. An approach that lends itself to generating and evaluating a wider range of reasonably good alternatives is preferable to one that, because of institutional or theoretical limitations, tends to limit the alternatives considered.

Finally, any method for evaluating alternatives needs to be selected in a way that shows respect for the people who will use it and be affected by its use. There is a tendency for experts to fall into patterns of behavior that communicate a message that "We know what's best and you should do it because we know what's best." Experience with the acceptance of new technology suggests that communicating such an attitude is likely to alienate the people being targeted by the experts. This attitude comes across in the prescriptions of some economists who recommend improvements in economic efficiency or the adoption of cost-benefit analysis, and in the advocacy by some planners of demand-side management or of alternatives to the automobile. Avoiding this attitude will not guarantee the acceptance of an approach or its recommendations, but it will not burden the process with unnecessary baggage.

3.2.2 COST-BENEFIT ANALYSIS

Under this approach, one identifies an alternative; estimates the costs and benefits incurred by the project in different time periods, relative to making no change; wherever possible converts the changes in costs and benefits to a unit of measure such as dollars; discounts costs and benefits to account for the time value of money; describes unquantifiable or unpriceable costs and benefits; and, if there are multiple alternatives, selects the one with the largest net present value (with some adjustment for unquantifiable costs and benefits). This approach is described in detail in a draft document prepared for the Federal Highway Administration (Parsons et al., 1995).

The principal advantages of cost-benefit analysis are its theoretical rigor, its acceptance by the economics profession, and its intuitive reasonableness. Some costs, such as vehicle operating costs, are relatively easy to measure.

However, some costs and many benefits are difficult to measure, at least for now. Some, such as changes in scenic landscapes are as yet highly place- and context-specific, which means that they must be evaluated in each locale and for each alternative rather than relying on regional or national values (which probably can be applied reasonably well to such benefits as savings in travel time). Others, including the cost of improving the system, are difficult to estimate at an early stage of the evaluation; small changes in design can have large costs, and such changes may be necessary to gain local acceptance of the project. Because of the breadth of costs and benefits that can accrue to a transportation investment, as well as the difficulty in estimating or measuring many of them, a full-scale cost-benefit analysis can be very expensive. Despite the theoretical rigor of the approach, our limited ability to measure costs and benefits prevents precise estimates and rankings. The Parsons, Brinckerhoff document, which argues for the use of cost-benefit analysis, notes that full-scale cost-benefit analysis is likely to be quite expensive and to require much more data than is encompassed in the typical transportation project EIS; they criticize EISs as being too descriptive and not analytical enough to support implementation of a cost-benefit approach (Parsons et al., 1995: 3-33)

Some simplifications may be possible. The direct costs and benefits for system users, and the direct societal costs to produce the benefits, can be estimated with reasonable confidence; focusing on them can greatly reduce the cost and complexity of the analysis. However, such simplification assumes that these costs and benefits encompass most of the important ones, and it may make it more difficult to consider costs and benefits that, while important, are difficult to quantify or monetize.

Finally, although cost-benefit analysis is intuitively understandable, applying it may involve steps that the public perceives as counterintuitive, because the analysis requires a grasp of economic reasoning that most of the public do not have. Some changes that the public might consider to be benefits, such as an increase in land values after a project improves accessibility, may be seen by economists as a double counting of benefits such as reduced travel time to system users (Parsons et al., 1995: 3-36). Unless the analysis can be presented in a way that the public can follow easily, it may be difficult to win support for decisions based on it. In addition, many people have deep-seated objections to some requirements of cost-benefit analysis, such as the assignment of value to human life or to a scenic landscape, even if it can be argued that government agencies do so implicitly anyway.

3.2.3 PROBLEM-ORIENTED ANALYSIS

Under this approach one would identify the problem or problems to be solved and a range of alternatives intended to solve them; estimate the costs of the alternatives and their effects on the problem(s); choose the alternative that yields the largest improvement per unit of cost, making allowance for factors not considered explicitly in the analysis.

The principal advantages of this approach are that it is intuitively understandable by the public, and that it can be structured to ensure consistent application across alternatives. An additional advantage is that one can structure a problem-oriented approach that would not be greatly different from much current practice, except for the fact that current practice appears not to accommodate alternatives that are partial as opposed to complete solutions to problems. One can also structure a problem-oriented approach that would encompass a form of integrated resource planning modeled after the process that electric utilities use. These two alternatives will be described in more detail later. The IRP approach is probably more likely to lend itself to generating a range of alternatives for evaluation than other approaches; one based on current practice may be more likely to generate a limited range of alternatives. The fact that a problem-oriented approach can encompass both of these may be seen by some as a disadvantage, but if this flexibility is exercised carefully we consider it to be an advantage.

One disadvantage of a problem-oriented approach is that it probably is sensitive not just to the general problem of which alternatives get evaluated, but also to the definition of the problem(s) to be solved, and the metrics for estimating the effects of changes to the system. For example, if the problem in a corridor is defined to be congestion, then the way that changes in congestion are measured can affect how alternatives are evaluated. Cost-benefit analysis avoids this problem by defining changes in one or more measures as costs or benefits, sorting out any double-counting, and then estimating a value for each.

Other disadvantages arise when a facility is perceived to have multiple problems. For example, in the Mt. Hood corridor case, the problems appear to be (1) congestion at peak periods, (2) safety, and (3) need for improved access across the Cascades. One disadvantage is the possibility of double-counting; in the Mt. Hood corridor case, the peak period congestion and the access across the Cascades are interrelated. Second, although a set of alternatives can be evaluated for its effect on each problem, each alternative is likely to have different levels of effectiveness on the problems. Some trade-off normally will be required among them (e.g., an improvement in safety that does not reduce congestion, vs. a large reduction in congestion that has minimal improvement in safety). Cost-benefit analysis avoids this problem by estimating a monetary value for changes in each of the problems and summing the resulting values. A problem-oriented approach could encompass this, or it could adopt the viewpoint that the trade-off is fundamentally political rather than economic and, after presenting the evaluations for each alternative, leaves the choice to the decision-maker. Using monetary values would not necessarily make this approach a simplification of cost-benefit analysis unless other conditions, such as elimination of double-counting and proper discounting of costs and benefits over time, were also met. Some decision-makers may prefer that the choice left to them not be so explicit, while others may welcome the opportunity. There is no guarantee that decision-makers will make consistent trade-offs between problems in different corridors or planning situations. However, if the decisions really are political rather than purely economic ones, there is no requirement that they be consistent as long as the decision-makers can be held accountable.

3.2.4 ESTIMATION OF DECISION-MAKERS' PREFERENCES

This approach is an extension of the second; it would query, survey, or interact with decision-makers in other ways to obtain information on how they trade off different attributes of transportation systems (for example, reduction in travel time vs. an increased severity of accidents from higher travel speeds, or a reduction in congestion against a decrease in the scenic quality of a stretch of road). The information, embodied in an expert system, weighting function, or other multi-attribute decision-making tool, could be used to help decision-makers improve the consistency of their own decisions, or to help other decision-makers understand how to focus their trade-offs. Such a system could also then be used by other analysts to understand how decision-makers would approach such trade-offs and build them into their analysis. In this way, decision-makers' preferences can be incorporated early in the analysis of a project, before detailed analysis of some alternatives is required. This approach has been the subject of much research by decision analysts.

However, this approach has a number of weaknesses. One is that it may be difficult to implement with consistency. While the system can help lead individuals to an outcome, as the individuals change (for example, members of a highway commission), so can the outcome. The approach only provides a decision-making aid; it doesn't make decisions. If the information is embodied in an expert system, as individuals respond differently to various paths that the system leads them down, the outcome may change. If the information is embodied in a set of formulas or procedures, it can restrict future choices, even if the preferences of the decision-makers or the public change with the passage of time.

A second disadvantage is the problem of identifying the relevant decision-makers. Moreover, decision-makers that are used to develop the system may not be the "correct" ones. For example, the preferences of the Transportation Commission may not reflect those of the public or the legislature. That is, unless a cross section of decision-makers is used to develop the system, such a tool may bias against a particular view that may be important in later project review.

Another concern is that the approach may be viewed as a way to circumvent public input. As noted, it is possible to use such an approach to introduce the preference of a particular group early in the analysis. This could be viewed either as taking this group out of the decision making loop, or as giving the group priority. Opposition to a particular project may stem from a perception of being left out, or a belief that another group was given an unfair advantage, and a group that might have otherwise supported a project may be persuaded against it.

3.3 ILLUSTRATIVE APPROACHES

Given the expense of conducting cost-benefit analyses for large numbers of alternative investments in a transportation system, and the difficulties noted for the approach that models decision-makers' preferences, we believe the most suitable approach will be either a simplified cost-benefit analysis, as suggested by Parsons et al. (1995), or a form of problem-oriented analysis. Below, we examine two variants of a problem-oriented approach. One is based on what we perceive to be the current approach used to evaluate alternatives, modified to allow trade-offs among alternatives that provide partial solutions to a problem rather than completely meeting a set of standards. A second is based on the approach to integrated resource planning adopted by electric utilities, which tends to generate a broad range of alternatives (although until the approach is actually implemented it is too early to determine how good these are). In both examples, we assume that the corridor is defined as having three problems: congestion during peak periods, safety, and a need for improved access between Portland and central Oregon, plus a strong desire to preserve the scenic beauty of the corridor, and to solve the problems at low cost.

The modified current approach for congestion would use the same kinds of estimates of level of service in the six-category scheme now used by ODOT and reported in the Draft EIS for the Mt. Hood corridor. Appendix A, which describes the six categories, notes an expected travel speed for each category of service (e.g., 60 mph for level A, falling to 30 mph for level E; and no expected speed for level F; one would have to be assumed for this approach).

The Draft EIS indicates that actual hourly traffic counts exist for 1992 and have been used to estimate the number of hours each month the corridor achieves different levels of service (Draft EIS, Table 3.2). The approach we suggest would estimate Table 3.2 for the year 2015 for each of the four alternatives analyzed in the Draft EIS. The Draft EIS indicates that estimates were made of daily traffic volume and level of service for the 100th-highest-volume hour for each of the four alternatives in 2015. Although we do not have information on how the Draft EIS estimates were actually made, these estimates imply an ability to estimate the table required for this approach, and we believe that the state of the modeling art would allow such an estimate. In addition, we would need some estimate of the number of trips of different lengths in 2015 for the four alternatives (e.g., trips from Portland to recreation areas within the corridor, local trips within the corridor, and trips traversing the corridor).

Given the traffic volumes and the equivalent of Table 3.2 for each alternative, one can calculate the number of hours traveled for the baseline alternative and the three investment alternatives:

([number of trips x length] /speed) = hours traveled

The Draft EIS contains estimates of the cost of the three investment alternatives plus a cost for changes made in maintenance for the baseline (no-build) alternative. These estimates can be used to calculate the travel hours incurred for each alternative, and the cost per hour saved by each investment alternative. One could go further and use local, regional, or national estimates of the value of travel time to estimate net travel time reduction benefits for each alternative, as is done in ODOT corridor studies. Extending this further would use estimates of changes in vehicle operating cost resulting from changes in operating conditions, if these were available, to move further toward a cost-benefit analysis.

The approach outlined here for congestion would allow selection of alternatives that do not fully deliver the level C minimum tolerable level of service set for the road, but that do make significant reductions in congestion (as measured by travel time) at lower cost per hour saved (or with larger net benefits). Note that by defining the problem as one of congestion and measuring congestion using travel time, the example does not assign any kind of value to the ability to serve larger numbers of users. Indeed, if (purely hypothetically) the growth in the corridorÕs use were to continue through 2015 for one of the build alternatives, at rates which were to cause levels of congestion equivalent to those projected for the baseline, the method outlined here would show no reduction in congestion and therefore no contribution to solving the problem. For this reason, it would be preferable to make annual estimates of Table 3.2 and traffic volumes in order to estimate a stream of travel savings rather than just a point estimate. Much of this information is available for construction alternatives from ODOT corridor planning. However, the corridor plans do not provide this information for non-construction alternatives.

For the problem of safety, the Draft EIS now estimates changes in the accident rates associated with the baseline and three investment alternatives. Although the changes reflect changes in road geometry, it is unclear from the description in the Draft EIS whether they consider the effect of differences in vehicle speed on accident frequency or severity, given that the different alternatives are expected to yield different average vehicle speeds. We would suggest using the rates reported, or better estimates if needed, and the traffic volume and distance traveled information collected for the congestion problem above, to calculate numbers of accidents and to compare the cost per accident avoided. Although the comparison could use cost per percentage reduction in the accident rate, the use of numbers of accidents would better lend itself to calculation of net benefits of accident reduction.

For the problem of access between Portland and central Oregon, the Draft EIS provides only qualitative descriptions of the economic impacts of the four alternatives on central Oregon and Portland. Economic impacts can be estimated using models of spatial interaction and regional growth. Many states maintain the ability to make forecasts of growth in different regions, either within state agencies or at universities or private firms. We would use this ability to make estimates of growth for Portland and central Oregon under the baseline and each of the three investment alternatives, using the impedance of travel time or travel cost estimated from the congestion problem to reflect changes in the corridor, plus any other planned transportation investments that might affect traffic between the two regions. Typical output from such models includes gross regional product and employment, either of which could be divisors for cost to allow comparison of economic improvement per unit of transportation expense. Simple models could likely be constructed for about $10,000, while more sophisticated models would cost two to three times this amount per region. Parsons et al. (1995) indicate that including employment or economic growth in a cost-benefit analysis would be inappropriate and that the values are likely to be small in any event. However, the Draft EIS makes it clear that the access problem is one that ODOT has to address, so it is desirable for there to be a measure for this problem.

The Draft EIS notes a strong desire to avoid damage to the scenic quality of the Mt. Hood corridor. The most straightforward approach to treating this within a problem-oriented approach would be to generate a consistent set of images of the baseline alternative and the four variations of each of the three investment alternatives at key points along the corridor, and conduct a contingent valuation study to estimate willingness to pay for different alternatives. Such a study should include users of the highway and persons who would view the highway from their residences or other locations in the corridor. One would then multiply the values obtained by an estimate of the number of affected persons. The number of residents of the corridor could be estimated using census data. An estimate of the number of road users could be made by asking information about frequency of road use in the Contingent Valuation (CV) survey and using this information to adjust the annual hourly road traffic volumes for multiple use. (See Appendix C for a detailed discussion of CV as a method to evaluate aesthetic costs and benefits).

We have noted that the net effects of all of these solutions could be monetized and used in a simplified cost-benefit analysis. However, doing so probably would require additional information on the direct user costs of the alternatives and, as noted above, it might preclude consideration of the trans-Cascade access which ODOT considers to be important. Hence, it might be preferable to simply present all of the alternatives, with their cost per problem-defined benefit, for ODOT consideration and public review.

The modified current approach sketched above could be extended further to consider the effects of demand-side management alternatives, provided that the analyst can estimate the effect of the demand reductions on traffic volumes, number of hours with different levels of service, number of accidents, and impedance used in the regional economic growth impact models. Although the three investment alternatives discussed in the Draft EIS contain some traffic demand management measures as well as highway construction, there is too little detail in the Draft EIS to determine how the effects of these measures were analyzed, and text in the document suggests that they would have little if any impact under investment alternative 3. It is likely that analysis of DSM effects would require some additional data and analysis beyond what was used in the Draft EIS or suggested above, and details of the data will be discussed in the next section. Given the data, it should be possible to use whatever methods were used in the Draft EIS, modified as above, to estimate the values necessary for the modified current approach. However, making the estimates may require some changes in how the models are used, either by estimating the effects of different combinations of alternatives or by iterating to estimate feedbacks between different alternatives. Again, this will be discussed in the following section.

An IRP-based approach would differ from the modified current approach by focusing more on defining the problems and developing alternatives targeted at solving them. It would require additional data on the behavior of transportation system users. In addition, it would require analysis of how behavior might change under different alternatives. Given these changes in behavior, one should be able to estimate the kinds of tables and information discussed above for the modified current approach.

The IRP-based approach would start by asking why people are using the transportation system, why they are using it in the ways that they do, which of these uses contribute disproportionately to system problems, and what alternatives are available to encourage changes in the uses that do. The overarching concept is one that people who use the transportation system do so primarily as part of the process of consuming a service; that transportation often is but one element of the service; and that there may be ways to modify or substitute other elements of the service to satisfy the consumer while changing how the transportation system is used.

This is a process akin to market segmentation and ideally it would draw upon techniques of market research, including surveys, interviews, and data analysis. The data reported in the Draft EIS lack some critical details needed for such analysis; using only the data reported in the Draft EIS the analysis would be quite limited. It would be expensive to go back and collect the missing data now; however, much of the missing data probably could have been collected at relatively little cost if done so at the time the data used in the Draft EIS were collected. Some of the key information needed, and how it might be collected, includes:

- ***Purpose of trips at different times of day on different types of day.*** The Draft EIS reports hourly traffic volumes for selected days for a recent year, and indicates that such data are available for the entire year. What we do not know, and would like to know in order to understand which uses are contributing to congestion, is how much of the winter peak use is actually for skiing within the corridor, how much is local, how much is for employment at ski resorts, how much is for travel between Portland and central Oregon, and what purposes the latter is serving (freight, shopping, commuting, recreation, etc.). This information could be gathered by a sample survey of corridor users. Some of it might also be collected by other participants in the provision of service, such as equipment rental shops, ski resorts, or other retail or service firms serving corridor users, who may develop the information for their own business purposes.

- ***Vehicle occupancy at different times of day on different types of day.*** The Draft EIS reports results of a survey by ski operators of the mode (bus or car) and car occupancy rates for their employees and patrons. What we do not know is how much of this occurs in the peak periods. If much of the peak-period use already is in carpools, then there is less scope for increased carpooling to reduce congestion than if much of the carpooling is now occurring at off-peak periods. Similarly, we do not know when buses depart or arrive, or their occupancy rates (although the latter probably can be obtained from information already in the hands of the resort operators or EIS preparers). And we have no information about why people are choosing the modes that they do. It is likely, given this type of activity, that the high vehicle occupancy rate reflects family members, friends and neighbors visiting the resorts as a group, rather than carpooling in the conventional sense; if they were not traveling together they might not be traveling at all.

- ***Relationship between transportation and other components of service***. The Draft EIS reports estimates of visitor recreation days within the Mt. Hood corridor, based on a survey for the Forest Service. What it does not report is how the visitors in various activities arrive, when they arrive or depart, and the rates of visitor days per trip for different kinds of activities. This kind of information is necessary to better understand various recreation market segments and their use of the corridor. It would also be necessary for estimating costs and benefits in a cost-benefit analysis. This information may have been collected in the survey but not reported in the Draft EIS; if not, it could have been, probably at relatively little additional cost.

- ***Latent demand and forecasted growth in demand***. At some level of congestion, users begin to reduce their use of the system, and some potential users decide to forego trips. A sample survey of existing users during congested periods would provide some information about trip frequency, and a sample survey of the Portland and central Oregon areas might be used to estimate latent demand. The Draft EIS notes that substantial increases are expected in the population of the Portland metropolitan area, and it uses projected growth rates in the area's population and vehicle miles traveled to set bounds on increases in traffic volume within the corridor. It is not clear how well actual growth rates in traffic volume have tracked growth in these other variables, and this relationship should be analyzed to estimate future traffic volumes.

It is worth noting that viewing the problem as one of use of recreational, access, or other services to which transportation contributes not only requires greater familiarity with the system users (understanding the customer), but also benefits from greater familiarity with other participants in the provision of these services (equipment rental firms, resorts, freight companies, etc.), who may have different perceptions of the problem and additional insight into how best to solve it. Given the greater emphasis in many state governments on partnering between agencies and private firms, as a way of reducing the cost of government services or improving agency performance, adopting this perspective may provide a framework for a transportation agency to undertake partnering and customer service. The Citizen's Advisory Committee and the Technical Advisory Committee are intended in part to accomplish some of these objectives, and their ability to fulfill this role should be carefully analyzed.

3.3.1 AN ILLUSTRATION

To illustrate the approach, we will take the example of recreational skiers who, from the information presented in the Draft EIS, are major contributors to peak congestion in the Mt. Hood corridor. Selection of this example assumes that the importance of this sub-market would be borne out by the more detailed data described above, and that the data indicate some scope for flexibility in changing the service. The previous discussion has indicated some conditions which might greatly restrict options for managing the demand from this sub-market, and further analysis might rule out specific options discussed below.

This market segment of corridor users has several advantages as an example. It is relatively easy to define. Although the skiers may come from a wide area, their destinations are fairly concentrated, and travel is concentrated in a relatively small number of time periods. The service that they travel to realize -- recreational skiing -- involves other service providers and organizations, such as resort owners, lift operators, and equipment rental firms. Partly as a result, the service already involves elements of payment and coordination among user and service suppliers; this allows greater ease of using two options for changing the service to influence behavior -- price of service components, and improved coordination among service components. As a disadvantage, recreational skiing does require travel and therefore is not amenable to the replacement of travel by other service components (as might be possible for the service of purchasing goods, which could be delivered by mail or by a retailer rather than picked up by the customer); there is, however, competition among ski destinations.

Having identified a sub-market, the next step is to identify options for reducing the sub-market's contribution to peak congestion. What kinds of things might be done to change behavior yet deliver the service that the sub-market wants? One would be to bundle transportation with other components of the service. Thus, ski rental operators might provide shuttle service from outside the corridor, or from their locations within it. Lift operators might include shuttle service, or discounts on parking for vehicles with more than two skiers. Another option would be to manage the ski experience differently, perhaps by offering expedited lift service at some times of day to entice skiers to schedule their trips to avoid peak congestion. The transportation agency might consider redirecting growth in demand for skiing, and some of the present market, to other destinations that are not as congested; this option probably would require coordination with other state agencies, as well as cooperation of the destinations involved. Another option might be to redirect some users to alternative routes, as one of the resorts apparently is now doing. Still another option might be to redirect some users to other modes (such as buses, shuttles, or carpools); this might be done by advertising, other public information, or by increasing the attractiveness of these modes (e.g., more frequent service, change in quality or convenience of the service). Although the Draft EIS indicates that charging tolls was not considered to be a legal option, in other corridors or circumstances setting tolls that vary with the level of congestion might also be an option. Much of the present sub-market appears to be a day market, with users leaving Portland to ski and returning the same day; it is possible that developing overnight accommodations and promoting their use could shift the travel portion of the service in ways that reduce congestion, although the Draft EIS also indicates concern about additional development in the corridor. Another option might restrict parking or increase the price for it, using the revenue to support other options.

Additional options might be identified based on discussions with other service providers and with corridor users. Other sources of options might be alternative types of recreation which have congestion problems (e.g., diving, wilderness use) or trade journals.

The next step in the process would be a combination of screening, design, and estimation of cost to the transportation agency. Electric utilities, based on their experience during the past five to ten years, are now in a position to make rough estimates of the cost and effectiveness of DSM options to quickly screen different options (e.g., "a 're-lighting' program can reduce demand by up to x kilowatts per customer at a cost of y dollars per kilowatt"). What one would like to have available for the transportation IRP-based approach are estimates such as "we can shift up to 1% of a population in a sub market from single-occupant autos to other modes at a cost of y to z dollars per person." Transportation analysts are not yet able to make such estimates, in part because the question is of a different sort than they are accustomed to asking, and in part because of the interdependence of transportation options (e.g., "we can shift up to 1% of a population in a sub-market from single-occupant autos to other modes at a cost of y to z dollars per person *unless you also improve traffic flow within the corridor, in which case we may not be able to shift more than .25%*"). It will take the development of a body of experience to guide the analysis before such information becomes available and easily used. For this reason, at the present time it may be best to conduct screening, option design, and option costing concurrently.

As noted, data about actual patterns of use might be used to screen out some of these options. Other screens that might be used include political feasibility (which might eliminate redirection to other markets); organizational feasibility (Are other providers willing to cooperate? What might it take to gain this cooperation?); and legal authority (which in this case appears to preclude congestion pricing and might preclude some forms of cooperation). In some instances, such as managing the quality of the ski experience differently, technical feasibility might preclude some options.

An alternative screen might be developed by taking the projected hourly traffic volumes for the baseline (discussed under the modified current approach above) and the least costly build alternative, and from them calculating the levels of reduction in volume required at different times of year to bring the corridor up to a desired level of service. If this exercise reveals that large reductions are necessary, DSM options that seem most likely to have the largest reductions might be screened first. If additional analysis (discussed below) indicates that they fail to achieve the necessary reductions, then it may become unnecessary to analyze options expected to have smaller effects. The ability to perform this kind of screening will be limited until experience is gained with the approach.

Estimation of the costs of DSM options and their effects therefore need to proceed jointly at this time. The costs (to an agency such as ODOT) are probably straightforward to estimate once an option is defined. It will be important to consider the cost not just of putting an option into place, but also of maintaining it, as transportation behavior can easily revert back to previous patterns if the option is discontinued or allowed to deteriorate. The difficulty, until more experience is gained, will be in specifying option designs that can achieve meaningful effects on system use, and estimating the effects of these options. Option designs will have to depend heavily on an understanding of the sub-market. For example, in an option to bundle shuttle service with ski rentals, what proportion of the market rents at locations where shuttle service might be feasible? This defines the maximum effect that such an option could have. How frequently would a shuttle service have to run in order to attract customers? Would the customers be willing to make appointments to meet a fixed shuttle schedule? How much would they be willing to pay for such a service, compared to what it would cost to provide it? How much of this cost would the rental firm be willing to cover, and how much would the transportation agency have to cover? For a given level of shuttle service, how many people might use it? At what times would they be driving if they did not use the shuttle? At what times would the shuttle run? How would these results change if the level of congestion in the corridor changed, either getting worse or better?

This is a great deal of information to be collected and analyzed. However, it is the kind of analysis that market researchers perform routinely, except that it is in the context of evaluating a new transportation "product." The data collection and analytical burdens probably will diminish as experience is gained. Once an option and its effects are defined for a set of traffic conditions, the effects can be used to modify the table of hourly traffic volumes discussed for the modified current approach, and the evaluation can proceed as sketched there. If, as in the investment alternatives presented in the Draft EIS, a DSM option is to be combined with a construction alternative, then the effect of the DSM alternative must be estimated based on the level of congestion or service expected for that construction alternative; it cannot simply be estimated for one set of traffic conditions and added to each of several alternatives that are expected to provide different levels of service.

The present state of practice may not permit rigorous analysis of bundled DSM options implemented simultaneously. Expert judgment to "tune" the analysis is likely to be necessary. In addition, as the effectiveness of the bundle increases, it is likely to become more difficult to estimate the actual effect, especially if there is latent demand for use of the corridor. This is a problem requiring additional research and development of modeling tools; however, such tools probably will have to be developed whether or not an IRP-based approach is adopted. For the remainder of the discussion, we will assume that the effects can be estimated for several bundles of options, some of which may involve construction of additional highway capacity and some of which may not. These effects on traffic volume can be analyzed using the modified current approach sketched earlier, and the costs per reduction in travel time for different alternatives compared as described there.

The focus of this example has been on congestion. It is not clear that any of the DSM options discussed here would have any effect on the accident rate, although if they do result in lower traffic volumes they would affect the total number of accidents, which would be analyzed as sketched for the modified current approach. If research were to establish a linkage between DSM and accident rates-either increasing or decreasing them-these effects would have estimated and used to estimate the number of accidents for each alternative.

For the trans-Cascade access problem, estimates of the hourly traffic volumes for alternatives involving congestion-oriented DSM could be used in the same way as sketched for the modified current approach. It might also be desirable to analyze the trans-Cascade market segment, both at times of congestion and at off-peak times, to understand how corridor users are using travel through the corridor to obtain other services. Analysis of this market segment could allow the transportation agency to identify DSM options that might improve service to the users and reduce use of the corridor during congested periods. Again, these joint effects may be beyond the present state of transportation modeling, but this is likely to improve, and expert judgment can guide the use of present models to obtain reasonable results. It should be noted that electric utilities have often found that reducing what they call "base load" demand (demand for service which is more or less constant during the day) during periods of maximum demand for service can be less expensive, or more effective, than trying to reduce demands that occur only during the periods of maximum demand. Thus even if the hourly trans-Cascade traffic volumes are relatively constant now, it may be worth looking at options to affect that portion of it which occurs during periods of peak congestion.

Finally, if DSM options are estimated to be effective, they should allow acceptable service to be provided in the corridor with less extensive levels of construction, and this can be analyzed using the modified current approach.

3.4 FEASIBILITY

We have sketched two versions of a problem-oriented approach to valuing and choosing among alternative transportation investments in the Mt. Hood corridor. One of these, the IRP-based approach, is an extended version of the other, because it uses the same basic method for valuing effects of the alternatives. However, we have considered the IRP-based approach separately because it is a markedly different approach to thinking about transportation planning. The IRP-based approach is more of a process for generating alternatives to be evaluated, and for stimulating creative thinking about how to define and solve transportation problems.

The IRP-based approach does require quite a bit of information beyond what is presented in the Draft EIS. Much of this information would be used to characterize the users of the corridor and how, when, and why they use it. This type of information probably could have been obtained at relatively little additional cost if its acquisition had been planned and carried out in conjunction with efforts to acquire the data reported in the Draft EIS. On the other hand, it would be expensive to go back and collect it now. This conclusion is not intended to fault the preparers of the Draft EIS; that document was prepared for other purposes than to support an IRP-based approach. Future data collection efforts, in this corridor or in others, might consider the possibility of such an approach.

The process of actually defining DSM options, estimating their effects on the transportation system, and doing so when multiple options are to be implemented simultaneously, strains the present state of transportation planning practice. However, this state is expected to improve as research is directed toward the kinds of problems and options that are driving transportation planning in many metropolitan areas: air quality, congestion with limited opportunities to expand capacity, and limited transportation budgets. A full cost-benefit analysis would also strain the state of the art, for the same reason: the benefits and costs depend in part upon changes in behavior that are, at present, difficult to capture using conventional modeling approaches.

The IRP-based example emphasized the use of DSM options. This was done because it illustrates a process of identifying options, involving the public and other service providers, and being willing to consider options that, historically, many transportation planning agencies have found difficult to consider against increases in transportation capacity. In the long run if the demand for service continues to increase, an increase in supply probably will be necessary. This is certainly true of electric utilities, on whose work we have based the IRP-based approach. Utilities have found that there is no "magic bullet" to reduce demand growth or avoid building new generating capacity. IRP involves attention to a lot of small details by the utility, in ways that are largely invisible to the customer, to provide a level of service that satisfies the customer and helps the utility solve its own problems. This is also likely to be true for transportation.

4.0 PROCESS ALTERNATIVES

Transportation planning in Oregon is largely driven by attempts to meet objectives related to level of service, or design deficiencies, and to address safety concerns through the construction of transportation infrastructure. While this is an over-simplification of a complex process with many competing goals and objectives, it seems to capture the essence of transportation planning. This process differs from a least-cost planning process in three major ways. The first is that least-cost planning puts primary emphasis on efficiency in meeting objectives. The second difference from more traditional planning is to expand the analysis to allow for non-construction options to be considered on an equal basis with construction options. The third difference is that flexibility in responding to future changes receives greater emphasis in least-cost planning than it appears to be in current transportation planning.

The efficiency objective is much more difficult to specify in transportation because there is a fundamental distinction between level of service requirements in the utility industry and those in transportation. In the utilities it is possible to simplify the analysis because revenue will be raised to meet level of service goals. In transportation planning, a fixed budget must be allocated among competing projects; this requires balancing of the costs and benefits of projects. Nevertheless, in each case, the fundamental question is how to most efficiently allocate resources rather than what should be built to satisfy service requirements.

Another way to characterize this important difference is to identify the costs and benefits of moving away from level of service standards in the two industries. In the electric utilities, failure to provide service typically results in large costs to consumers. Brownouts may damage electrical equipment or service failures may result in severe discomfort. Hence it has been decided that substantial changes in the level of service provided to customers are not an option. This may not be the most cost effective level of service to provide; but once the criteria are set, the analysis for least-cost planning is greatly simplified. In transportation, the method of funding prevents this from happening. It may be that the costs of deviations from service levels are not as severe; but even if they are, the limited budget means that they must be evaluated since they will occur somewhere in the system.

Failure to use a pricing system to fund transportation services thus creates two fundamental differences between planning for transportation and for the electric utilities. Because the customer is not charged directly for the service, there is little incentive to conserve on use as the cost of providing transportation service increases. Further, there is no expectation that revenue will be raised to provide all the service identified as being desired. Hence, while the utility planner picks among projects to meet projected demand and expects the price of electricity to change so as to generate the required revenue, the transportation planner is expected to allocate the fixed revenue among the various projects proposed. The utility planner can confidently expect that level of service goals will be met throughout the system most of the time while the transportation planner can not expect anything similar. Hence, the cost to customers when level of service goals are not met is a minor issue to utility planners, but evaluation of this cost must be a more important concern for the transportation planner.

Because of the difference in objectives, the utility planner does not have to be concerned with whether not meeting objectives has a bigger cost for one group than for another, but each transportation project that is funded precludes others from consideration. Hence, although each project creates benefits, asking whether it creates benefits or not is not a sufficient question. Rather, the benefits must be weighed against the cost and against the benefits that the money could generate in the next best project. This latter issue is why isolated application of cost-benefit analysis to specific projects can not yield an overall determination of the project's desirability. The important question is not whether a project creates benefits that are greater than costs but rather whether the project creates net benefits per dollar invested that are greater than the net benefits per dollar invested in other projects. If an isolated project is funded because it has benefits that are greater than costs but this precludes funding of other projects with even greater net benefits, the outcome will not be an efficient one.

Hence the first recommendation is that planning at all levels incorporate more cost-benefit analysis. However, this is not a recommendation for major evaluations of all options. Rather the cost of doing the analysis argues for a set of screens that incorporate cost-benefit principles, with full cost-benefit analysis being done only in certain atypical cases.

Demand management, especially in isolated projects, is unlikely to allow for achievement of level of service requirements. If the level of service requirements are treated as a major objective of the planning system, then demand management options will typically be precluded. This system might make sense if the level of service requirements were in fact going to be met in all parts of the system. There would be little point in investing in demand management if there would still have to be major investments to achieve service goals. However, if the demand management options achieve modest benefits for low costs, their ranking in a cost-benefit framework would be much enhanced. In this case, the net benefits from a limited amount of funds may be maximized with a large set of small expenditures with small payoffs relative to a smaller set of large expenditures with limited benefits.

Whether demand management options achieve higher benefits per dollar than construction options is an open question, but it does appear that current planning procedures do not allow for their consideration on an equal basis with construction options. Hence, the second recommendation is that procedures be developed to generate information on the cost and effectiveness of non-construction options, and that procedures make fair comparisons of a variety of options be developed.

Technology and public policy both hold out the potential for major changes in the demand for transportation infrastructure at some point in the future. Electric utility planners found that trend projections of the growth in demand did not serve them well, yet transportation planners seem to use similar trend projections as the basis for much planning. The third recommendation is that some consideration be given to evaluating the potential impact of major changes in technology or policy on the value of various types of transportation investment. In particular, consideration should be given to the possibility that some types of investments are likely to have high payoffs under a variety of possible outcomes while others may only be desirable under a relatively narrow set of circumstances.

4.1 PROCESS

The process of least-cost planning is perhaps the most important determinant of the outcome. Many different types of process can be labeled as least-cost planning since there is no widely accepted definition of just what this means for transportation. Just as the utilities have moved away from this term, it may also be necessary to find a more descriptive term in transportation. The term integrated resource planning is now widely used in the utilities, but it is not clear that this terminology is consistent with what we are trying to do in transportation planning. Integrated transportation planning has been suggested as an alternative term. Before trying to agree on terminology, it may be better to discuss how the planning process might differ under least-cost principles.

As the Mt. Hood corridor Draft EIS suggests, an important step is to determine the goals of the transportation planning process. Just as the goal of generating electricity at the lowest cost per unit did not turn out to be a least-cost approach to utility planning, so, too, meeting a level of service standard for the lowest cost will not do as a least-cost standard for transportation planning. This implies that the first step in a least-cost process must be to determine just what the goals of the system are and how they can be met.

Oregon's transportation planning process appears to have all of the necessary steps to establish goals. For example, there is a requirement for a statewide transportation plan that takes account of different travel requirements and different modes. This allows for consideration of non-travel issues and the development of a general approach to transportation issues. Further, there are land-use goals related to transportation and various federal rules and regulations. In fact, the problem may be that there are too many goals in the various planning documents. The utility industry has a clear advantage in least-cost planning because the basic goal is simply to meet expected service requirements.

In transportation planning, service requirements are replaced by service goals and the goals are themselves an attempt to simplify the planning process. By setting service standards, transportation planners can avoid the more complex questions involved in making trade-offs among costs and benefits of alternative transportation systems and standards. This observation is not a criticism of the practice, but it does indicate a potential conflict with efficiency principles. In effect, the adoption of service standards simplifies the type of analysis that needs to be done for service planning. Some simplification is essential to actually accomplish anything. For example, it would be foolish to analyze all possible road width options each time new construction is evaluated. Further, the specification of standards provides for better connectivity of the system of roads. However, there is a trade-off. Standards are meant to simplify the planning process, but there must be room to question the efficiency of specific standards. At a broad level, some evaluation of the costs and benefits of specific service standards, safety features, and design characteristics is desirable, especially the costs and benefits of slight changes in the standards. This type of analysis should probably be done at the national level. At a more specific level, some consideration of the costs and benefits of meeting standards needs to be incorporated into the planning process so that efficiency in allocating resources can be a reason for not meeting standards.

Hence, the first step in setting goals requires some evaluation of the entire set of laws and regulations that affect the transportation planning process. A variety of actions over a long period of time have resulted in a set of rules and procedures that define transportation planning. The result may not be consistent with efficiency goals. Some evaluation of the trade-offs between cost and other considerations must be made to determine whether to maintain existing restrictions. It is at this level that certain types of decisions are made that affect planning at the more detailed stages. The Access Oregon Highway designation is an example of the effect that planning at the system level can have on lower level planning efforts. This designation is intended to achieve certain specific economic development goals for the state as a whole. Due to the priority given to this part of the transportation system, roads designated as Access Oregon Highways have a higher priority for funding than similar roads without such designation.

The high-level approach to least-cost planning will also have to develop standards that can be used to influence project prioritization at later stages of the planning process. The specific mechanisms do not appear to be any different than those currently in use, but the goals specified in the planning process may be different if evaluated with the goal of identifying the least-cost provision of service.

At least partly, the issue is one of specifying exactly what one means when calling for more transportation service. Much of the current interpretation is, at least implicitly, that providing more transportation service is accomplished only by expanding capacity. The change in the utilities required more focus on the end use and less on the means of achieving the end use. The same must also happen in transportation. The end use is not vehicle miles traveled, and, almost as importantly, it is probably not mobility or access either. The former goal is very concrete but not consistent with least-cost planning principles while the latter ones are more consistent with the principles, but may not be concrete enough to lead to useful choice mechanisms. Hence, part of the problem is to redefine what we want from a transportation system. **To the extent that the goal is efficiency, the cost-benefit evaluations increase in importance.**

Finally, the use of pricing to achieve efficiency objectives should not be dismissed. Economists have long argued that the major problem with the transportation system in urban areas is the failure to charge for use at peak periods. Use of the price system forces people to weigh their benefits from using roads against the cost. This is an effective method to both generate information on the value placed on transportation and to alter behavior to be more consistent with efficient choices. It is generally expected that the amount of capacity required will be much greater in the absence of pricing than would be required with peak pricing. **A future change to a congestion pricing system would affect the benefits associated with expansion of capacity today, and this possibility should be considered when setting goals for the system.** For example, a variety of estimates have been made of the effect of congestion pricing on traffic generation. Rough estimates can be generated from existing studies, or specific models can be developed for $15,000 - $75,000, depending on scope and level of sophistication.

4.2 SPECIFICATION OF GOALS

The examples in the Mt. Hood case started by looking at the various end users of the system to identify their objectives in using the road. This appears to be a reasonable way to address the goals for the transportation system. Hence, evaluation of a transportation corridor could start with a very careful enumeration of users and potential users of the system. This should include information on origin and destination as well as issues of timing. Next, evaluation of the goals that are being achieved by this use of the transportation system is needed. Finally, constraints on alternatives should be identified. For example, work trips are very important in generating peak period congestion in urban areas. Yet many of these commutes also include other activities. It may be possible to reduce the amount of congestion without reducing the number of commutes by reducing the amount of diversion for non-work related activities. For example, proponents of mixed-use development contend that more such development would have precisely this effect.

Similarly, at a very aggregate level it may be determined that the transportation system can provide the same level of service at lower cost by increasing the density of development. While this may be correct, it would not typically be taken into account at the corridor planning level. Hence, some types of incentives might be added to the planning process. Rather than giving higher priority to roads identified as Access Oregon Highways, it might be more effective to give higher priority to improvements for areas that have developed at relatively high density. This suggests that the current planning strategy be continued but with modification of the goals at each level of the process.

Prioritization of funding is a very powerful method to identify the relative importance of goals. By offering higher priority to Access Oregon Highways, goals associated with this part of the transportation system are elevated relative to goals associated with other parts of the system. This is a critical consideration in periods of tight funding. The all or nothing implication of major construction projects not only deters consideration of alternatives for the designated corridor but also prevents consideration of many small projects that might cumulatively have much greater benefit.

4.3 PUBLIC INPUT

The use of public input is important in the existing transportation planning process, but the process is still oriented toward construction. The public input element should be expanded to include discussion of alternatives to construction for dealing with specific objectives. While there is always a potential problem with the public suggesting impractical approaches, there should be some way to elicit and evaluate responses at a level comparable to those used for build alternatives. This would require evaluation of both cost and effectiveness for various suggestions. The evaluation of both is likely to be outside of the general expertise of existing staff. Hence, data on the effectiveness of various alternatives and evaluation of their costs and effects would be necessary. This must be built up over time as it was in the utilities. The situation will be somewhat more difficult than it has been in the utilities because the differences in factors that affect transportation are much greater. People are simply more sensitive to the environment under which they travel than they are to the environment related to electricity provision.

Again, the importance of standards in simplifying the planning process should not be underestimated. The development of standards related to demand management, land use, transit, or other non-construction approaches is in principle possible. Some such standards are specified in the Oregon Transportation Plan (ODOT, 1992b); however, there is little evidence that these standards were developed with explicit consideration of efficiency as an objective. Hence, the recommendation is to use public input to identify and refine alternatives to construction and then to use rigorous analysis of costs and benefits to define how these alternatives are to be incorporated into the planning process. One possible method is to develop standards for the alternatives. These standards could be used to supplement the standards that exist for construction in comparing different approaches to transportation issues.

The other major difference is that the alternatives are likely to be outside current experience. As noted earlier, an alternative such as park and ride lots with shuttle buses will have many difficult hurdles to implementation. However, unless these are addressed constructively, there will be no demonstration projects to show feasibility or to be evaluated to determine if they are worth repeating. There must be an opportunity for proponents of such systems to generate suggestions and to question assumptions that lead to rejection of alternatives. No one person will be able to consider all of the possible variations on a policy nor all of the potential pitfalls. Transportation is much more complex in this regard, but the benefits of demonstration projects should not be underestimated. While ODOT has pursued demonstration projects in the past, they have been almost exclusively related to construction. The least-cost planning approach in the electric utilities draws heavily on demonstration projects that were non-construction attempts to meet service requirements.

4.4 FLEXIBILITY AND UNCERTAINTY

The existing transportation planning process does not acknowledge the unknown component of the future demand and technology. There is also limited consideration of changes in policy and their effect on the transportation system. This is related to the entire question of generating forecasts. Most elements of the forecast rely on certain assumptions about activities exogenous to the transportation system, such as population growth; but various elements of the process are endogenous to the system. For example, the level of usage is determined both by the demand for transportation associated with population growth and other changes but also by the supply of transportation resources. Hence, forecasts that do not take account of both the reaction to changes in the supply and changes in transportation policy are not adequately addressing the uncertainty associated with the forecasting process.

Two parts of the forecast seem particularly questionable. The first is the assumption that pricing will not be used. While pricing is not currently feasible and is not politically acceptable, the possibility still exists, especially if there are some federally funded demonstration projects. Even if the probability seems slight, the case should be analyzed because it is likely to have an immense impact on the net benefits of additional capacity. Also likely to have a substantial impact are changes in the technology used to control traffic. So-called intelligent transportation systems have the potential to increase flow rates for existing roads. At the very least, such considerations will lead to a broader range of possible outcomes to consider. Further, careful analysis of the impact of policies like congestion pricing on the need for new construction may increase support for such policies.

4.5 LCP STRENGTHS AND WEAKNESSES

Least-cost planning has the potential to substantially improve the efficiency with which transportation resources are allocated; however, it is not a cure-all. Its major strengths are opening the investment decision process to the consideration of non-traditional alternatives, setting in place a process by which these alternatives can be more objectively compared to construction, and highlighting efficiency and cost control as central goals of the planning process. Its major weakness is the potential cost of carefully evaluating a wide range of alternatives and a lack of agreement on the specific goals of the transportation planning process.

Another problem that is likely to be encountered in least-cost planning is the existing system of laws and regulations that may prevent the implementation of least-cost alternatives. Legal restrictions on the use of congestion pricing and the many service level requirements are examples of factors that may preclude least-cost solutions. Finally, the process can identify alternatives that are least-cost but it can not in itself make these alternatives politically feasible. Hence, there is great uncertainty as to how the process will develop, and the trade-offs between the efficiency gains that may occur from better planning and the ability to incorporate other factors in the process.

A related issue in determining the strengths and weaknesses of the process is that the specific form has yet to be determined. Least-cost planning is still in the concept stage, so the strengths and weaknesses of the specific form will depend on the form chosen and its methods of implementation.

4.6 COMPATIBILITY WITH EXISTING POLICIES AND PROCEDURES

Least-cost planning is compatible with existing statements related to estimating cost, benefits, and cost-effectiveness of transportation alternatives, but it may be less compatible with current practice. For example, cost-benefit analysis of transportation alternatives is clearly within the scope of LCP; however, current methods of implementation might not be because they are not consistently applied to a broad range of projects. Hence, if a cost-benefit study is done for only one project, that project may have positive net benefits; however, other projects may have even greater net benefits. If the other projects are not evaluated, the outcome would be to fund the project that was evaluated. Another example would be a determination that a particular improvement was a cost-effective method to address a design deficiency while an LCP approach might determine that the design deficiency was not a high priority for investment funds.

Hence, the issue is more the existing application of procedures than the principles that underlie the procedures. We see little need to reinvent the basic methods. Rather, LCP calls for a more consistent application of the methods to a broader range of alternatives. To apply these methods to a broad range of alternatives will require some development of low-cost screening that can be applied systematically. Thus, a priority for implementation would be to develop low-cost procedures to roughly estimate costs and benefits of various alternatives. Further, some consideration of a range of possible future outcomes could be incorporated into planning at a relatively low cost while careful modeling may be difficult and expensive. While full implementation may be costly and take years to develop, redesign of existing procedures to be compatible with least-cost principles does not seem to require major changes.

Some of the costs and changes that are required are not unique to the LCP process. Poorly designed use of cost-benefit, cost-effectiveness, and other efficiency-oriented methods is a problem for any planning process, and correction of deficiencies in such methods of analysis should not be considered part of the least-cost planning process. For our purposes we have considered the compatibility of the processes that would be used with least-cost planning and the processes that are called for in various federal regulations, such as ISTEA; and we find no basic conflict. However, there is no guarantee that the techniques will be used correctly when applied in a least-cost framework if they have not been used correctly in other situations.

There are many statements in both federal and state documents that focus on the efficiency or cost-effectiveness of the transportation system. For example, the Oregon Transportation Plan (OTP) (ODOT, 1992b) specifies that the system should be efficient. Under Goal 1 it states:

> *The system must be efficient. Transportation agencies need to make decisions about whether to add lanes to freeways or to build light rail lines based on their full costs, including the cost to the environment and the community.*

Further, Policy 1B, "Efficiency" states:

> *It is the policy of the State of Oregon to assure provision of an efficient transportation system. The system is efficient when (1) it is fast and economic for the user; (2) users face prices that reflect the full costs of their transportation choices; and (3) transportation investment decisions maximize the full benefits of the system. (Full benefits and costs include social and environmental impacts, as well as the benefits of mobility to the users, and construction, operations and maintenance costs).*

However, efficiency goals are sometimes in conflict with other goals. The OTP also states that the system must meet "transportation needs." While this statement does not inherently contradict least-cost principles, it is in practice not consistent due to the specification of "needs." Needs implies that there is some minimum below which unacceptable problems arise. Further, a need must be satisfied; and this desire to satisfy needs may preclude more efficient efforts to provide transportation services. This is stated explicitly in Policy 2E:

> *It is the policy of the State of Oregon to define and assure minimum levels of service to connect all areas of the state.*

On the other hand, the OTP also specifies that the system should provide "more flexibility in funding, investment and program options," and this is an important component of the least-cost approach.

Similar ambiguity arises in other documents. ISTEA requires each state and urbanized area over 50,000 population to adopt a twenty-year transportation plan and to "consider a range of transportation options designed to meet the transportation needs (both passenger and freight) including all modes and connections." Hence, there is some direction about wider mode choice in looking at transportation options, but the underlying emphasis is on investment options to increase capacity.

The implication of these examples is that although transportation policies are aimed at promoting efficiency and expanding options, demand management has not been a major consideration. Since least-cost principles argue for a more explicit consideration of demand management options, many of these requirements are at least partially inconsistent with the least-cost approach.

This does not mean that there is no consideration of transportation demand management or transportation system management. For example, in the OTP, Goal 4 states:

> *The transportation system must be managed so that steps are taken to ease the demands on the system before new facilities are constructed. For highways this can be done by reducing peak period travel, improving the traffic flow and encouraging the use of transit, bicycling and walking. In the future, congestion pricing or toll system may be an important element of urban freeway management.*

Further, Action 1b.3 specifies:

> *Use demand management techniques to reduce vehicle miles traveled in single occupant automobiles, especially during peak hours of highway use.*

Finally, the 1991 Oregon Highway Plan (ODOT, 1991: 27) states: "One method of reducing the urgency of needs lies in reducing demands on the highway system." Hence, there are ample guidelines to encourage the use of demand management techniques.

We conclude that there are many statements of goals and policy that support the least-cost planning approach, but there are other statements of policy that may be in conflict or which are not complementary. While policies seem to be evolving toward more consideration of a broad range of transportation alternatives, the practice of transportation planning may be changing more slowly, at least in part due to standards that are in place regarding service levels. These standards need to be re-evaluated in terms of the costs and benefits of achieving them, and more consideration should be given to allowing deviation from standards where high costs or low benefits make meeting the standard inefficient.

5.0 LCP DEVELOPMENT PLAN

In general, least-cost transportation planning can be characterized as starting from the basics of cost-benefit analysis and including consideration of a wide range of alternatives, uncertainty, and flexibility. It appears that the transportation planning process could be changed to incorporate least-cost planning principles, but that there is not a clear-cut set of changes that will accomplish this. Rather, there are a series of issues that must be addressed within the planning process.

While it is clearly an oversimplification, the current transportation planning process focuses on meeting service requirements. This focus tends to limit consideration of alternatives to construction in meeting transportation system requirements. In particular, the limited budget for construction means that transportation projects that meet level of service requirements in specific areas may not be the best use of available funds. Rather, more explicit consideration of the benefits and costs of construction and other options may indicate that many small projects generate greater net gains than a smaller number of big projects; but none of the smaller projects may meet the relevant service standards.

Hence, the first change needed is more explicit balancing of costs and benefits when allocating transportation resources. This does not mean that formal cost-benefit studies are needed, but rather that a screening mechanism that incorporates costs and benefits be adopted.

The second change is to more explicitly consider non-construction alternatives and to find an evaluation method that considers these alternatives on an equal basis with construction alternatives. At present, incomplete and unreliable information regarding the effectiveness of alternatives limits their consideration. The electric utilities responded to similar gaps by conducting experiments that were carefully evaluated. The data from these experiments forms a substantial part of the least-cost planning process in the utilities, and a similar effort will be needed for transportation if least-cost principles are to be effectively applied.

The third change is to more explicitly consider the possibility that transportation requirements and policies will be substantially different in the future. Current planning practice is based on projections of current trends, but the investments being made are intended to last for long periods, when the trends may have changed. In particular, the utilities explicitly plan for future changes in the demand for electricity and for flexibility in meeting changing conditions. More consideration of such possibilities are likely to change the relative desirability of various approaches to meeting transportation needs.

A number of actions are recommended for consideration in attempting to adapt least-cost principles to transportation planning. These include the following:

- Evaluation of the impact of laws and service standards. Constraints implied by legal restrictions and service standards may carry substantial obstacles to least-cost outcomes.

- Specification of screening criteria. While full cost-benefit reports are not likely to be cost-effective methods to rank a large number of options, some criteria must be developed to allow this type of screening.

- Expand the set of alternatives considered. Methods to expand the types of actions evaluated and to compare them to construction options on an equal basis must be developed.

- Fund and evaluate demand-management and other alternatives on an experimental basis.

- Specify the relationship between the different types of planning and the methods to incorporate findings from "higher level" planning into more specific applications. For example, analysis of specific projects may not be able to adequately consider affects on the whole transportation system, but methods to incorporate these effects into the project analysis may affect the choices made.

5.1 COST

The cost of further LCP development will depend greatly on the method of implementation chosen. It appears that some principles of LCP could be adapted to existing planning processes at virtually no cost; however, a full-scale evaluation of all transportation alternatives in all cases could be enormously expensive. The next step is a determination of how the LCP process could best be incorporated into ODOT planning procedures. We recommend that the approach used in the utilities, of incremental experimentation and evaluation of alternatives, be used. This requires that specific no-build alternatives be identified and evaluated. **The knowledge base does not exist to facilitate major changes in the current planning process simply because we lack information on the effects of many demand management and land-use options.** Changing emphasis to more consideration of costs and benefits for investment options is likely to occur as part of the multi-modal investment criteria project, and should not require additional expenditures to be made compatible with least-cost planning.

A major cost of the early implementation of least-cost planning in the utilities was the evaluation of experimental demand management programs. As a knowledge base developed, individual utilities could draw on previous evaluations to gauge cost and effectiveness for their applications. It appears that something similar must be done for transportation. Currently, the best data is for construction alternatives, and even this is not as good as one would desire when making large investments that will be in place for decades. The biggest weaknesses in current modeling and forecasting procedures are difficulties in addressing changes in behavior and land use in response to transportation alternatives. Yet these are the types of responses that must be evaluated to determine the net benefits of the alternatives, whether supply or demand-side.

The cost of developing more sophisticated models will most likely be borne by the federal government. There are a variety of model development efforts currently underway. The more problematic issue is the evaluation of experimental programs.

The major recommended cost for the State would be a study to evaluate the impact of existing laws and regulations on the ability to do least-cost planning. The cost of such a study would be about $100,000. Table 5 summarizes the studies in this report, and provides a very general estimate of their cost.

Table 5.5: Cost Estimates of Studies Discussed in This Report

Subject	Ref. Page	Cost Estimate
Feedback effects of congestion and other travel conditions on trip generation, duration, purpose, mode and route choice, and scheduling in the Mt. Hood corridor	pp. 24-25	$75,000 - $100,000
Stated preference analysis of the effects of congestion pricing in the Mt. Hood corridor	pp. 24-25	$50,000 - $75,000
Simplified "generic" cost-benefit analysis	p. 28	$50,000 - $75,000
Regional economic models	p. 32	$10,000 - $30,000
Survey of Mt. Hood corridor travelers to analyze trip purpose, vehicle occupancy, time of travel, etc.	pp. 33-34	$15,000 - $30,000
Market analysis of demand-side management opportunities related to recreational travel in the Mt. Hood corridor	p. 36	$50,000 - $75,000
Evaluation of the effects of changes in policy and technology on travel demand and highway capacity needs	pp. 40-44	$250,000 ++
Evaluation of costs and benefits of service standards	p. 41	$50,000 - $250,000
Congestion pricing models	p. 42	$15,000 - $75,000
Evaluation of park & ride shuttle service to Mt. Hood recreational destinations	p. 44	$15,000 - $30,000
Evaluation of laws and regulations affecting the implementation of least-cost planning	p. 49	$75,000 - $125,000

5.2 SOURCES OF FUNDING

The cost of specifying and evaluating alternatives to construction in meeting transportation objectives is likely to be high. However, there is potential for funding from several sources. The Federal Highway Administration has provided funding both to generate a handbook on least-cost planning for transportation and for modeling efforts to evaluate least-cost planning alternatives at the regional level in the Puget Sound area. Further, the Puget Sound Regional Council has funded studies in light of a mandate from the Washington State Legislature to implement a least-cost approach to transportation planning. Further, some energy and air quality considerations open the possibility for funding of evaluations that are likely to generate energy savings or air quality improvements.

A recommended strategy would be to assess what has been accomplished by the Puget Sound Regional Council in adopting the principles of least-cost planning to transportation issues and to attempt to work jointly with them in refining the process. It appears that their efforts and the efforts of ODOT are very complimentary. The PSRC has focused on the evaluation of different broad approaches to transportation policy at the regional level, while this report and the efforts of ODOT have focused more on the issues of adapting the process to the needs of an operating agency. Both issues must be addressed before implementation of least-cost principles can occur, so there appears to be substantial room for collaboration. Further, the potential for these procedures to be adopted by other agencies and their compatibility with ISTEA mandates and other federal regulations argues for the possibility of federal funding for further development.

6.0 CONCLUSIONS

The general concept of least-cost planning is adaptable to transportation planning. However, the specific methodology is still not well-defined and there are substantial knowledge gaps regarding the effect of various policies. Uncertainty is greater regarding the travel effects of demand management and land-use policies, but then it would also be a mistake to accept forecasts related to the impact of construction options as being without significant uncertainty.

Transportation planning is guided by many rules and regulations. Over time, more and more of these are consistent with the principles of least-cost planning. However, there are still items that can be interpreted as being in conflict with least-cost planning. Further, the policy framework may change more rapidly than the planning procedures. There is a well-established set of performance guidelines that affect discussion of transportation systems, yet these performance standards may divert attention from alternative approaches to transportation issues.

Presently, the transportation sector is in many ways similar to the utility sector when least-cost planning was first being considered there. There are increasing impediments to new construction as a response to perceived increases in demand and there is a growing recognition that the existing system is not being used efficiently. Further, there is little information on the effectiveness of various non-construction alternatives in responding to increases in demand for transportation services.

Faced with this changing landscape and limited information on how to proceed, some caution is warranted. Nevertheless, **it does appear to be both feasible and desirable to shift the transportation planning process in the direction of least-cost planning.** We have avoided trying to provide a rigorous definition of what least-cost planning would be or even any assertions regarding whether the term is the appropriate one. Rather, we characterize least-cost planning as an attempt to improve the efficiency of transportation system investments, primarily by considering alternatives to new construction as methods to provide transportation services.

Transportation planning in Oregon occurs at a variety of levels, but the more important distinction for our purposes is between higher level planning and project planning as defined by the Transportation Planning Rule (Oregon Administrative Rules, 1995). Under this definition, "Transportation system planning establishes land use controls and a network of facilities and services to meet overall transportation needs." It is at higher levels that the principles of least-cost planning appear to offer the most guidance. Demand management systems, pricing systems, and land use systems are among the options that should be evaluated along with road construction, transit construction, and other supply oriented options.

This is a complex set of issues, but a number of other transportation planning organizations are considering these issues, notably the Puget Sound Regional Council. Better information on cost and effectiveness as well as on consumer acceptance of various options will allow for more cost-effective system planning. Emphasis is placed on the need for evaluation of the effectiveness of different transportation options in meeting transportation goals. The most serious difficulty with this exercise at this point are the many unsubstantiated claims of effectiveness for various alternatives. For example, Pickrell (1992) documents that light rail lines have uniformly cost more and carried fewer passengers than projected. Least-cost analysis must be based on realistic projections rather than wishful thinking. This type of information will be difficult to incorporate into the planning process because of the uncertainties, but it is essential if there is to be any real progress.

Related to the system level analysis is the need for a review of existing rules, laws, and goals to determine their consistency with least cost planning. The example in this report noted the impact of the Access Oregon Highway designation. There are no doubt good reasons for this designation, but one side effect may be to make it harder to provide a consistent application of least-cost principles to transportation planning. **We recommend that a careful review of such rules and regulations be conducted.** Another potential option, congestion pricing, often shows up well when evaluated from the least-cost perspective, but it is typically dismissed as being prohibited by law. Where such laws do prohibit least-cost options, they should be identified and evaluated in that context. Even if it is decided that rules, laws, and goals that are not fully consistent with least-cost planning are to be retained, there may be some specification of circumstances where exceptions might be warranted.

Once general characteristics of a least-cost transportation system have been identified, incentives should be developed to insure that all transportation planning is consistent with the weighting determined at the system level. For example, if certain levels of land-use density are specified as being part of the least-cost system, then areas that meet these densities may be given higher priority for transportation investments; or if some form of demand management is identified as being part of the system, areas that effectively implement such policies might receive similar prioritization. Such incentives are likely to be important for incorporating system considerations without trying to do detail planning at the system level.

The other area for the use of least-cost planning is at the corridor or MPO level. At these levels, demand management pilot programs should be instituted and evaluated. This would be consistent with the process of development in the utilities. As experience with programs grows, the knowledge of effectiveness will allow for better planning in other areas; but someone must do the experimental programs to generate data to evaluate. The key issue here is to truly consider such options and to determine what is needed to make them work. Poorly planned demand management programs can easily be shown to be ineffective, but there are likely to be circumstances that will make success more likely. Again referring to our Mt. Hood example, shuttle buses are not feasible without some changes in other policies; but there may very well be options, such as higher parking prices at ski areas, that would make it feasible. A significant part of least-cost planning is to determine what needs to be changed to make various options feasible.

Project level analysis is most problematic from a least-cost perspective. It does not appear that there is a great deal that can be done at this level of planning to incorporate least-cost principles. At the level of individual projects, ability to fit into the transportation system appears to dominate other considerations, and individual projects will be judged primarily on that basis. If the system decisions have been made on a least-cost basis, then this approach should be consistent. However, **project prioritization should be sensitive to efficiency considerations, with those contributing more to system efficiency receiving higher priority for funding.**

Finally, funding for the transportation system has typically come from various taxes rather than from pricing of the system; but system pricing offers an opportunity to increase the efficiency of the system and fund the system, allowing reduced reliance on other taxes. Hence, the funding system must also be considered in a least-cost approach to transportation planning. Aside from the potential to raise revenue, the funding system must also be considered if funds for transportation are to be used for purposes other than construction. Oregon currently restricts the use of road funds. This appears to increase support for certain taxes that are viewed as being paid by road users, but it does restrict ability to consider some other options for transportation system improvement. These restrictions on funds as well as the potential to raise funds will also have to be considered in designing a least-cost planning system.

It does not appear that Oregon's transportation planning system needs dramatic overhaul to move in the direction of least-cost planning. Rather, the system needs to be re-evaluated in light of the efficiency considerations inherent in least-cost planning. This would consist of evaluations in line with cost-benefit analysis or cost-effectiveness analysis at the system level, and experimentation and evaluation of more demand management programs at the corridor or MPO level. For example, the cost effectiveness analysis of travel time savings done for corridor studies could form the basis for a cost effectiveness comparison of corridor projects. Identifying and building on the elements of least-cost planning already in place will be the most cost-effective method to implement least-cost transportation planning in Oregon.

7.0 REFERENCES

Brookshire, D.S., and D.L. Coursey. 1987. Measuring the value of a public good - An empirical comparison of elicitation procedures. *American Economic Review* 77 (4): 554-556.

Carlson, Samuel H. 1994. Analysis of the effects of snow and ice conditions on highway operations and capacity. master's thesis, Department of Civil Engineering, Oregon State University, Corvallis, OR.

Citizens Advisory Committee. 1994a. Mt. Hood corridor study. Meeting minutes. February 2.

Citizens Advisory Committee. 1994b Agenda. January 10.

Cummings, R.G., G.W. Harrison, and E.E. Rustrom. 1995. Homegrown values and hypothetical surveys - Is the dichotomous choice approach incentive-compatible? *American Economic Review* 85 (1): 260-266.

Edrington, Michael S. Memo to U.S. Forest Service. September 16, 1993.

Kaiser, Jef. Interview by Lois Bronfman. March 9, 1995

Kaiser, Jef. Memo to file. August 3, 1994.

Lee, Theresa. Interview by Lois Bronfman. February 13, 1995.

Lee, Theresa. Letter to technical advisory committee. File Code: C003-1473.

Mt. Hood Corridor Study Newsletter. 1994. Milwaukie, OR: ODOT Region 1, January.

Oregon Administrative Rules. 1995. Transportation planning rule. 660-12. Salem, OR.

Oregon Department of Transportation. 1995. Overview of statewide corridors (draft). Salem, OR: ODOT, April.

Oregon Department of Transportation, Re-Engineering Core Team. 1994. *Case for Action and Re-Engineering Methodology for Project Selection and Development*, Salem, OR: ODOT.

Oregon Department of Transportation. 1994a. 1993-1998 Six-year transportation improvement program - Highway construction and development projects (Region 1: project scheduling report). Salem, OR: ODOT.

Oregon Department of Transportation. 1994b. Benefit-cost methodology for projects under the local rail freight assistance program (public review draft). Salem, OR: ODOT.

Oregon Department of Transportation. 1994c. Oregon Rail Plan (public review draft). Salem, OR: ODOT.

Oregon Department of Transportation, Transportation Development Branch. 1992. Best management practices for transportation/land use planning (working draft). Salem, OR: ODOT.

Oregon Department of Transportation. 1992a. *Oregon rail passenger policy and plan* (agency report). Salem, OR: ODOT.

Oregon Department of Transportation. 1992b. *Oregon Transportation Plan.* Salem, OR: ODOT.

Oregon Department of Transportation. 1992c. Development review guidelines (review draft). Salem, OR: ODOT.

Oregon Department of Transportation, Highway Division - Planning Section Highway Plan Group. 1991. *Highway Division: 1991 Oregon Highway Plan.* Salem, OR: ODOT.

Oregon Department of Transportation. 1981. *US-26 Corridor Study.* Salem, OR: ODOT.

Parsons, Brinckerhoff, Quade and Douglas, Inc. 1995. *Least-Cost Planning: Principles, Applications and Issues.* prepared for the U. S. Department of Transportation. Federal Highway Administration, Office of Environment and Planning. Washington, D.C.

Pickrell, Don H. 1992. A desire named streetcar: fantasy and fact in rail transit planning. *Journal of the American Planning Association*, 58 (2): 158-176.

Robinson, Donna. Memo to file. C003-1473. Feb. 1, 1994.

U.S. Department of Transportation, Federal Highway Administration, and Oregon Department of Transportation. 1995. Mt. Hood corridor environmental impact statement (draft). Salem, OR: FHWA and ODOT.

U.S. Department of Transportation, Federal Highway Administration, and Oregon Department of Transportation. 1994. Mt. Hood corridor environmental impact statement (preliminary draft). Salem, OR: FHWA and ODOT.

U.S. Department of Transportation, Federal Railroad Administration. 1993. *Environmental Externalities and Social Costs of Transportation Systems: Measurement, Mitigation and Costing: An Annotated Bibliography.* Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Transportation, Federal Transit Administration. 1994. Revised measures for assessing major investments: A discussion draft (FTA policy paper). Washington, D.C.: USDOT.

U.S. Forest Service. Letter to Theresa Lee. May 4, 1990.

Ulberg, Cy. 1994. *Multimodal Evaluation in Passenger Transportation.* Washington, D.C.: Transportation Research Board.

APPENDIX A

OPTIONS INITIALLY IDENTIFIED IN THE MT. HOOD CORRIDOR PROJECT

APPENDIX A

OPTIONS INITIALLY IDENTIFIED IN THE MT. HOOD CORRIDOR PROJECT

Major Capacity Improvements

1. Add passing lanes throughout the two-lane segments.
2. Provide a minimum of three lanes throughout the corridor.
   - 2a. Provide two lanes in the peak direction by converting the middle lane to a reversible lane.
   - 2b. Convert the middle lane to a high occupancy vehicle lane.
3. Add one lane to the two lane segments and one lane to the three-lane segments.
4. Improve segment of old alignment in the vicinity of Laurel Hill to complement existing alignment.
5. Add a new alignment in the vicinity of Enola Hill to complement the existing alignment.
6. Improve Still Creek Road to serve as an alternate parallel route.
7. Provide a minimum of four lanes throughout the corridor; turn lanes would be added where appropriate.

Operational/Safety Improvements

1. Provide turn lanes.
2. Add paved chain-up areas.
3. Provide eight-foot shoulders.
4. Designate more "no passing" zones.
5. Provide scenic viewing pull-off areas.

Travel Demand Management

1. Provide regularly scheduled bus services.
2. Provide charter bus service.
3. Provide train service.
4. Encourage people to carpool.
5. Develop a vanpool program for employees.
6. Institute congestion pricing.
7. Encourage travelers to use alternate routes.

8. Implement a parking supply and pricing management system.
9. Provide transit and ride-sharing incentives, such as lift ticket or other service discounts, preferred parking locations, etc.
10. Provide pedestrian and bicycle facilities.

Maintenance

1. Improve sight distance by vegetation cutting/clearing.
2. Improve snow and ice removal.
3. Modify snow plowing and storage procedures.

Enforcement

1. Provide strict enforcement of traction device laws.
2. Provide strict enforcement of speed laws.
3. Post an adjusted speed based on real time driving and weather conditions.
4. Require headlights to be on during daylight hours.

APPENDIX B

DESIGN HOUR VOLUME RECOMMENDATION

APPENDIX B

DESIGN HOUR VOLUME RECOMMENDATION

The design of highways should be based on factual data relating to traffic. The general unit of measure for traffic on a highway is the average daily traffic (ADT), defined as the average total volume during a 24-hour period. This average usage does not consider variations in month of the year, day of the week, and hour of the day. To ensure an efficient design, a design hour volume (DHV) should be chosen to accommodate the peak traffic conditions but not be underutilized for the majority of the time.

AASHTO GUIDELINES

The guidelines for choosing DHV in the American Association of State Highway and Transportation Officials 1990 manual, *Geometric Design of Highways and Streets*, read as follows:

> The traffic pattern on any highway shows considerable variation in traffic volumes during the different hours of the day and in the hourly volumes throughout the year. It must be determined which of these hourly traffic volumes should be used in the design. It would be wasteful to predicate the design on the maximum peak-hour traffic of the year, yet the use of the average hourly traffic would result in an inadequate design. The hourly volume used in the design should not be exceeded very often by very much. On the other hand, it should not be so high that traffic would rarely be great enough to make full use of the resulting facility.

A further qualification, as on page 56, states: "Some congestion would be experienced by traffic during peak hours but the capacity would not be exceeded. A check should be made to ensure that the expected maximum hourly traffic does not exceed the capacity."

The intent in these AASHTO guidelines is to chose a DHV which results in the most efficient and optimum use of the facility <u>without exceeding the capacity.</u>

Common design practice is to use a curve showing the hourly traffic volume during the year, in a descending order, to determine the DHV. <u>On average, for a typical roadway with low to moderate traffic fluctuations</u> (rural or urban), the 30th highest hour (30 HV) is taken to be the DHV. The reasonableness of choosing the 30 HV becomes apparent by choosing an hour higher or lower than the 30 HV. A higher hour would result in the facility being over-built. The curve is flatter to the right of 30 HV, indicating many hours when volumes are not much less than the 30 HV.

The use of the 30 HV as the DHV is also helpful for future scenarios. As a percentage of ADT, the 30 HV varies only slightly from year to year in spite of significant changes in average daily traffic (ADT). In urban areas, the 30 HV is almost equal to the p.m. peak hour volume, while in rural areas the 30 HV is 12 to 18 percent of the ADT.

The use of 30 HV is mostly adequate for typical roadways with low to moderate traffic fluctuations, as long as the capacity is not exceeded. However, there are roadways with unusually high and seasonal traffic fluctuations (like on some recreational routes) on which weekend traffic during a few months is far in excess of any traffic during the remaining months of the year. These fluctuations result in high peak-hour volumes relative to ADT, high percentages for high-volume hours, and low percentages for low-volume hours. Even though the 30 HV may still be the same percentage of the ADT, the percentage criterion may not be applicable.

For seasonal variations, the AASHTO manual (p. 56) states:

> Economy dictates a design that results in somewhat less satisfactory traffic operation during seasonal peaks than on rural roads with normal fluctuations, and the public generally will accept such conditions. On the other hand, design should not be so economical that severe congestion results during peak hours. It may be desirable, therefore, to choose an hourly volume for design, which is, say, about 50 percent of the volumes expected to occur during a few maximum hours of the design year whether or not it is equal to 30 HV.

The only restriction in choosing the DHV being that the capacity of the facility is not exceeded by expected volumes.

MT. HOOD RECREATION AREA VOLUMES

The high traffic fluctuations in the Mt. Hood Recreational Area is typical of situations where the 30 HV would not be appropriate. Peak traffic volumes generally occur on winter and summer weekends. Traffic volumes at other times are relatively light. Traffic flow during the peak traffic periods is typically very directional, with approximately 80 to 90 percent of the total traffic coming from one direction. The existing volumes (1993) already exceed capacity for a few highest hours of the year.

ASSESSMENT OF DESIGN HOUR VOLUME OPTIONS

The 30 HV (approximately 1430 vph) is much higher than the typical hourly volumes during the peak periods. Designing for that volume would require more capacity, which would not be fully utilized during most of the year. This would result in the facility being over built.

The use of 50% of the highest hour volume (about 450 HV) translates into designing for about 900 vph two-way volume (roughly 700 to 800 vph in peak direction). It's expected the existing facility would be able to accommodate this volume with an acceptable LOS. However, the capacity of the facility would be exceeded. This means capacity will be exceeded during the seasonal highest hours (existing peak directional volume is 1353 vph) and would therefore violate the capacity restriction guideline for DHV. It should also be noted that the vast majority of hourly traffic volumes during winter and summer peak periods is over 900 vph.

RECOMMENDED DESIGN HOUR

Under the circumstances, it would be preferable to select a DHV somewhere in between these two options, one which took into account a reasonable percentage of the peak hour volumes, and which avoided traffic volumes exceeding the capacity of the facility during the maximum volume hours. The 100th highest hour is about 1200 vph in both directions. This design volume would accommodate the majority of the typical peak hour volumes during the peak periods. Based on the characteristics of the corridor the 100th highest hour is a more appropriate design hour volume than either the 30 HV or 50% of the highest hour volume.

APPENDIX C

ESTIMATING THE VALUE OF AESTHETICS

APPENDIX C

ESTIMATING THE VALUE OF AESTHETICS

The Draft EIS indicates that preserving the scenic quality of the Mt. Hood corridor is important, both to users of the corridor and to Native Americans in the region. Any method for evaluating and comparing alternatives will therefore need to be able to deal with the problem of valuing aesthetic effects of transportation investments.

Putting a value on aesthetics such as a scenic view is not a simple task. There is no formal market for views of mountains or across a clear blue lake. These aesthetic qualities are considered non-market goods. Therefore, before the economic implications of increasing road construction costs to enhance (or avoid damaging) the aesthetic quality of a roadway can be fully understood, it is helpful to discuss how the value people place on such changes can be determined.

There are several ways to value a non-market good such as aesthetics. Two of these, the travel cost method (TCM) and the contingent valuation method (CVM), are potentially appropriate for roadway aesthetics. Each has it own strengths and weakness that will be discussed briefly. Finally, the appropriateness of each for a project such as the Mt. Hood corridor is considered.

The TCM was developed in the 1960s as a method for exploring people's values of environmental commodities such as fishing in streams and lakes or particular hiking trails. The method assumes that the amount of money that someone is willing to spend to go to a particular site is the value of that site to them. Consider a family that decides that there is a particular view of Mt. Hood that they want to use as backdrop for a day's outing. They could have chosen to stay at home and have the same lunch, play the same games, and have the same conversation, but instead they have chosen to spend money to go elsewhere. Therefore, it is reasonable to assume that the extra expense of traveling to the picnic area with the scenic view is a measure of the value that the family puts on this view.

Costs that would be considered as part of the value of the site would include vehicle operation (gas, oil, wear-and-tear), any special equipment that needed to be purchased especially for this trip (possible camping permits if it were a camping trip), and the value of the time it takes to get to the site.

This last point, as has been discussed frequently, can be difficult. In the simple case where an individual takes time off from work, gets in a windowless bus and is taken to the site, the measure of the cost of time is the earnings that the person had to give up. However, if we move away from this situation and suggest that people take this trip in their free-time, and that they experience utility from the trip itself (there are interesting views along the way, or a person simply enjoys the drive), this simple proxy of time cost is an overestimate.

It is important to note that any cost that is incurred at the particular site that also would have been incurred elsewhere are NOT counted as part of the value of the site. So, for example, the cost of the picnic lunch itself should not be considered in the TCM. The lunch would have been consumed if the picnic had taken place at the site of interest, at home, or even on the way to a different place. It is important that the only costs that are considered are the ones that are unique to the place in question.

The strength of this method is that it relies, albeit indirectly, on market data where price provides a signal of value. Thus, while a picnic area with a view of a meadow is itself a non-market good, a measure of value based on traditional, better understood market signals can be determined.

However, there are also weakness to this approach. If the stop at a particular site is not the express purpose of the trip, the costs associated with the stop are difficult to disentangle from the total cost of the trip. For example, if a family is going from Bend to Portland to visit relatives and stops along the way at a scenic view, what portion of the total travel costs are associated with this particular stop? Further, if a particular site is very crowded when the picnickers arrive, and they move on to another site, is it right to assume that they value the other alternate site more simply because they traveled further to get there? What is the role of non-site characteristics such as congestion?

Therefore, it is important to have another method for valuing non-market goods. In particular, a method that does not rely on indirect data would be desirable--a method that does not determine the value of the non-market good through amounts paid for other (related) market goods. The CVM is one such direct method.

In its most simple form, CVM asks people directly what their willingness-to-pay (WTP) is for a specific non-market commodity. For example, an investigator would ask people to report how much they would be willing to pay to insure the preservation of a particular scenic view along a particular stretch of road. A very simple exercise would be to ask in some type of survey (mail, phone or personal): "What would you be willing to pay in increased fuel taxes in order to move a road from its present course to one that insures that it doesn't cut across an open meadow?" The reported WTPs can then be summed up to get the total WTP for an area. This then can be used in the calculation of economic benefits from undertaking a particular project.

The same survey can be used to collect information about the respondents to aid in understanding the bids themselves. Further, questions within the survey can be used to educate respondents on the matter at hand. That is, unless a respondent has given an issue, such as ground water contamination, some serious consideration (e.g., where does it come from, how does it affect me both negatively and positively, how much might it cost to clean up, etc.), he or she can't be expected to make an informed, reasonable bid. Therefore, the CVM instrument not only is used to derive an individual's value for a non-market commodity, it helps to inform the respondent about the commodity, and allows the researcher to collect data on the respondent to make inferences about the larger population.

While CVM is a relatively recent development, it has gained wide acceptance. It has been used to determine values for Superfund sites and other CERCLA lawsuits for many years. Further, CVM has played an integral role in the legal proceedings related to the Exxon oil spill off of Prince William Sound in Alaska. Other applications involve valuing changes in visibility in metropolitan areas, ground water quality, and location of possible hazardous waste sites and routes for transporting hazardous wastes.

One of the strengths of CVM is that it is a direct method. The investigator is not relying on data collected from secondary sources, or data collected for other purposes to infer value. The values come directly from the source to the researcher. This eliminates some of the negative reaction to other methods, which can be criticized for "mining" data.

Another strength is that CVM can be used on commodities where indirect methods like TCM are infeasible. As noted above, a TCM study may not show significant values for a particular site because there is no place to stop and enjoy it. Yet CVM's direct nature should capture this value if it does exist.

There are drawbacks to CVM, and because of the relative newness of this technique, researchers do not have all the answers. One of the drawbacks is called hypothetical bias. Here, because the researcher is asking a purely hypothetical question (e.g., "What are you willing to pay for increased water quality or to preserve a scenic view?"), the values may not be accurate; hypothetical situations yield hypothetical values.

A related question is whether individuals understand all the salient aspects of the good they are asked to value. As an example, when asked about the contamination of ground water, most people felt that work should begin right away and be more extensive than might be recommended by an expert. This was in part influenced by the perception that ground water traveled faster than its actual pace of only a few inches a year. Once this aspect of ground water was explained, WTPs elicited by the mechanism dropped significantly.

Information is also a concern when discussing the elicitation scenario that is presented to the respondents. In the example above, it was suggested that an increase in the gas tax would be used to cover increased road construction costs to preserve a particular view. In terms of economic theory, it doesnÕt matter if we describe the preservation action as moving a road, or increasing cost to take more care of the environment, or having increased mass transit that makes the expansion unnecessary. The issue is how much is the view worth to an individual, not whether the individual prefers one project over another. However, this may not be how the respondent perceives the issue. A respondent may not be willing to pay to increase the road's capacity regardless of how the view is preserved, believing instead that the road is already too large and that there should be an increase in mass transit. Therefore, this person may say that she is unwilling to pay any increase in taxes not because her value for the view is zero, but because she does not like the scenario presented to her.

The same holds true for the payment vehicle, in this example an increase in the gasoline tax. If a person believes that he is already paying too much in taxes, he might answer the valuation question by saying that he would not pay anymore taxes even to preserve the view. Again, this does not necessary mean that he has a zero value for the view, only that he doesn't believe that to pay for it in taxes is right.

Therefore, responses that come from a CVM may contain protest bids (e.g., "I already pay too much in taxes"), and scenario rejections (e.g., "We don't need bigger roads"). Presently research is being undertaken to deal with these responses but, as with much CVM work, it is only in its earliest stages.

Another problem that is now being investigated involves understanding exactly what people are valuing and why. This may at first seem like a trivial problem, when we are asking about a particular view from a particular spot on the road. Yet research is finding that the values elicited may not be for this particular view, but for scenic roadways across the nation, or a bid for environmental preservation, or a bid that conforms with an individual's moral system (e.g., "It is right to give to environmental causes"). In one case (Kannamen and Knetch, 1992) when subjects were asked to give a value for increasing water quality in a particular lake, and for all the lakes in the area, respondents overwhelmingly gave the same value for both. The problem is compounded further as we try to use the method to determine national values for a particular good. For example, what is someone in New York willing to pay to avoid oil spill damage in Alaska?

These weaknesses, and the relatively slow pace of the research to resolve them, are in large part due to the fact that CVM was pressed into service before it was well understood and researched. Issues such as Natural Resource Damage Assessment, and Superfund litigation have called for non-market valuation methods before they were completely understood. Much of our understanding of CVM comes from actual valuation studies. Lessons learned from one study are then transferred to the next.

Further, as noted, many of these concerns and weaknesses are currently being investigated. Much of the work is going on in experimental economic laboratories all over the world (Brookshire and Coursey, 1987; Cummings et al., 1995). Further conferences sponsored by both government and private sectors bring together experts from all over the world who are investigating such issues. The CVM is becoming more and more refined as we continue to use it and understand its strengths and weaknesses.

It is important to note in the case of both TCM and CVM that the results are very site-specific. That is, values for one recreational site in one study may not be transferable. If a CVM study were taken of a particular view of Mt. Hood from a particular highway, the estimate may not be valid for another view of Mt. Hood from a different highway. It would be inappropriate to attach one set of values from one view to another view even if the circumstances were very similar.

This is also true for the travel cost method. Each recreational site or picnic area has many different characteristics. These characteristics can be controlled for within a specific area, but not as easily across regions. Therefore to try to generalize these results across locations, even if they address the same problem, is not recommended.

A CVM study for this particular project would cost approximately $200,000 which includes all the survey development and final data analysis. Development, pre-testing (including focus groups) and data analysis would take approximately five months. The actual data gathering is difficult to estimate and depends on whether it is done by phone, mail, or personal visit.