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16. Abstract

In this study, the project staff pursued three main objectives. The first objective, the subject of Report 1356-1, was to define the concept of full-cost analysis in the context of a multimodal transportation evaluation framework, including the identification of all cost components of transportation systems and a summary of estimations made in previous research of the unit costs of these components.

The second objective, the subject of Report 1356-2, was to develop a multimodal full-cost analysis computer model (termed MODECOST) that would incorporate the findings from Report 1356-1 and that would facilitate the application of multimodal full-cost analyses.

The final objective was to apply the concept of multimodal full-cost analysis via case studies of transportation corridors for several MPOs in Texas. The results are documented in a series of reports, Report 1356-3 through Report 1356-7. According to the findings, the evaluation of transportation systems from a multimodal full-cost perspective can result in recommendations for transportation improvements that differ significantly from recommendations made based on consideration of initial capital investment costs. Additional results are summarized in this report.

The understanding and application of the full-cost concept in a multimodal framework provides valuable input to the transportation planning process. Consequently, charging the full cost of transportation directly to the users will theoretically result in the most efficient use of public funds for transportation systems.

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DEVELOPMENT OF AN URBAN TRANSPORTATION INVESTMENT MODEL: EXECUTIVE SUMMARY

by

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Research Report Number 1356-8F

Research Project 0-1356

Development of an Urban Transportation Investment Model

conducted for the

Texas Department of Transportation

in cooperation with the

U.S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

December 1996

IMPLEMENTATION RECOMMENDATIONS

Recommendations for implementation of the findings of this study are as follows:

1) Planners should not evaluate the cost of potential transportation system additions or improvements based solely on the initial capital cost that will be incurred by the Department or any other entity. Rather, the cost should be evaluated from an annualized life-cycle perspective.
2) Evaluate the full costs of implementing and utilizing a potential transportation system addition or improvement, not just the costs incurred directly by the Department. The full cost includes user costs and external costs as well as agency costs.
3) Consider potential transportation investments from a multi-user system perspective, not just from the perspective of a particular agency or mode. Various measures of effectiveness (MOEs) of the transportation system might be considered such as:

- minimizing the full, annualized life-cycle cost of the system;
- minimizing the individual's cost of living;
- maximizing accessibility;
- maximizing mobility;
- maximizing "livability"; and
- other MOEs.

The implementation of transportation system additions and improvements that result from this approach might require the designation of a completely flexible federal or state transportation fund rather than, or in addition to, the current State Highway Fund or the semiflexible federal funding system. Establishment of a flexible Metropolitan Transportation Fund is another potential requirement that would also necessitate legislative action. Further research could (1) look into the transportation investment decision-making process, (2) identify how to quantify various MOEs, and (3) develop weights for the various MOEs.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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Research Supervisors

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SUMMARY

Multimodal transportation planning has become a high priority for state transportation officials since the passage of the Intermodal Surface Transportation Efficiency Act of 1991, known as ISTEA. ISTEA mandates that the state transportation planning process address 23 different planning factors. As summarized in the 1994 Texas Transportation Plan, these factors include:

- the consideration of the overall social, economic, energy and environmental effects of transportation decisions, and;
- the consideration of the life-cycle costs of transportation systems.

In response, the 1994 Texas Transportation Plan "establishes specific policies, strategies and potential actions to guide the planning, development, and preservation of a multimodal transportation system in Texas." Specific strategies and potential actions that support this research effort include the following:

Strategy	Potential Action
Strategy 15.2 Avoid and mitigate the environmental impacts of transportation facilities.	**Potential Action 15.2.2** Promote public awareness of the differing environmental costs of transportation alternatives.
Strategy 19.2 Broaden advance planning to ensure multimodal collaboration in project planning, design, right-of-way designation, and acquisition.	**Potential Action 19.2.1** Include transit, bicycle, and other modes in advance planning. **Potential Action 19.2.2** Establish design standards and practices applicable for incorporating other modes.
Strategy 22.1 Focus on projects with greatest return on investment.	**Potential Action 22.1.1** Use benefit-cost analysis in evaluating projects to be included in the Statewide Transportation Improvement Program to ensure the greatest return on investment. **Potential Action 22.1.2** Use life-cycle costing in developing project cost estimates and in evaluating projects for the Statewide Transportation Improvement Program to ensure consideration of all costs.

The elaboration of these strategies and potential actions in the Texas Transportation Plan indicates an increasing awareness by decision makers and transportation agencies that all costs of transportation systems should be considered and that potential multimodal components of a system should be considered in the transportation planning process.

In this study, the project staff pursued three main objectives. The first objective, the subject of Report 1356-1, was to define the concept of full-cost analysis in the context of a multimodal transportation evaluation framework, including the identification of all cost components of transportation systems and a summary of estimations made in previous research of the unit costs of these components.

The second objective, the subject of Report 1356-2, was to develop a multimodal full-cost analysis computer model (termed MODECOST) that would incorporate the findings documented in Report 1356-1 and that would facilitate the application of multimodal full-cost analyses.

The final objective was to apply the concept of multimodal full-cost analysis via case studies of transportation corridors for several MPOs in Texas. The results are documented in a series of reports, Report 1356-3 through Report 1356-7. According to the findings, the evaluation of transportation systems from a multimodal full-cost perspective can result in recommendations for transportation improvements that differ significantly from recommendations made based on consideration of initial capital investment costs. Additional results are summarized in this report.

The understanding and application of the full-cost concept in a multimodal framework provides valuable input to the transportation planning process. Consequently, charging the full cost of transportation directly to the users will theoretically result in the most efficient use of public funds for transportation systems.

EXECUTIVE SUMMARY

INTRODUCTION

The full costs of auto, commercial truck, and mass transit modes of travel are subsidized to varying degrees under current transportation finance mechanisms. Such subsidies occur when the costs of construction, rehabilitation, operation, and/or use of a transportation system are not fully and directly paid by users of that system. The full costs are eventually paid by society at large, but not directly by the users of the system at the time of travel.

Theoretically, the presence of subsidies results in an inefficient use of public funds for transportation purposes because the policy decisions made as to the type of system to implement are affected by the perceived cost of the system. If the perceived cost of the system is not equal to the actual full cost, then transportation policy decisions will be made based upon erroneous assumptions.

Thus, this research project, sponsored by the Texas Department of Transportation, undertook the assessment of the full costs of transportation systems and the application of the full-cost analysis concept in real-life case studies of transportation corridors in various MPOs across the state. By providing a comprehensive measure of effectiveness for potential multimodal transportation system investments, full-cost analysis represents a valuable tool for transportation policy makers.

FULL-COST ANALYSIS

In the United States, the highway network has been provided by an array of mechanisms, many founded on federal and state economic and strategic programs paid or underwritten out of general taxation. The farm-to-market system favored agriculture and rural development, the interstate system provided for defense needs, and, more recently, a number of new toll roads compensate for financing shortfalls. However, the provision of highways is a two-stage process. First, the system must be constructed and thereafter improved and maintained. Subsequent funding after the initial provision of highways is incurred principally because of automobile and truck use, and so vehicle owners, rather than the general taxpayers, have been expected to pay for improvements and maintenance. Two of the themes associated with this policy are the benefit principle — users pay in proportion to benefits received — and the incremental cost principle — where users pay in proportion to the highway engineering costs incurred by the use of their vehicle type (Walters 1968). The basic objective in this approach is one of equity, and this is now central to most cost allocation studies (Euritt et al. 1993).

However, complications arise when we start to define all the costs associated with auto and truck transportation on U.S. highways. First, there are the direct costs associated with motor vehicle operations, which are familiar to many through personal auto ownership. Next there are the bundled costs that appear in the prices charged for other goods and services, like parking at work and around shopping malls. Finally, there are those costs, such as for air pollution and noise, that are borne by others unconnected with the vehicle travel. Where costs are not taken into account — or internalized — in the prices charged to the highway user but impact negatively on the social welfare of others, they are categorized as external and have traditionally been ignored, particularly in the cost allocation process used to determine equitable vehicle operation (or user) charges. It should be remembered that social welfare and external costs have precise definitions in the field of public policy analysis. Though they have frequently been reduced to the level of techno-jargon by many, they link into concepts of social welfare in economics that have been developed over the last 150 years (Button 1979). In simple terms, external costs exist when an individual's action results in a reduction in welfare to others in society which is not taken into account in the individual's decision-making process.

Since the U.S. highway system is now both mature and successful, more attention is being paid to all types of user costs. Numbers of vehicles and vehicle miles of travel continue to grow, causing substantial congestion and a reduction in service levels during many hours of the day. Traditional user costs, based on vehicle operations, fail to measure the full impact of these effects. For example, costs linked to air quality and noise fail to be recognized entirely in the current mechanisms for pricing vehicle use. Full-cost analysis — including all monetary and non-monetary costs — is now becoming recognized as a legitimate policy mechanism, one capable of addressing the demand for highway use and the consequences related to that use. Public policy needs to recognize these not only to formulate more equitable policies with respect to highway users, but also to develop more effective multimodal policies and strategies.

Delucchi defines the all-inclusive economic costs to society of using motor vehicles as the sum of explicitly priced private sector costs, bundled private sector costs, public sector costs, external costs, and personal nonmonetary costs (Delucchi 1996). He argues that a social-cost analysis (identical to the full-cost definition used in this study) can help in a number of important ways, namely, to:

1. estimate efficient prices for roads, emissions, and other costs;
2. evaluate the costs of alternative transportation investments; and
3. set priorities to reduce transportation costs.

Researchers and policy makers in Europe and North America are now promoting the evaluation of highway and multimodal investment programs from a social-cost or full-cost perspective (ECMT 1994; Royal Commission 1994; Litman 1996). The 1356 study researchers decided that the case for adopting full-cost analysis to meet project objectives was convincing and appropriate. As techniques are developed to more accurately determine, first, the magnitude of costs and, subsequently, its value, this approach can only strengthen in importance.

STUDY REPORTS

An understanding of the full costs of multimodal transportation systems is vital to intelligent transportation system planning. Such understanding requires not only the articulation of abstract concepts, but also the real-world application and evaluation of these concepts. Toward this end, this study has produced eight reports. The first report (1356-1) provides an introduction to the concept of full-cost analysis and summarizes findings from previous research on the identification and valuation of the full costs of transportation systems; it also describes the development of a full-cost model dubbed MODECOST.

The second report (1356-2) describes in detail which cost components are addressed by the model and how they are estimated. The next five reports (1356-3, 1356-4, 1356-5, 1356-6 and 1356-7) describe the full-cost analysis case studies conducted utilizing the MODECOST model in existing transportation corridors located in several MPOs across the state. This final report (1356-8F) summarizes study findings.

STUDY ORGANIZATION

Full-cost categories for three modes of passenger travel are identified in this study: auto, bus, and light rail. Unit costs for each of these categories were researched through a literature review and through discussions with Texas Department of Transportation staff and other transportation agencies across the country.

The computer model developed to facilitate the application of the full-cost analysis concept was designed to be user-friendly. It provides pull-down menus for various user inputs, including travel demand data, mode splits, and unit cost data. Based upon the research described above, default unit cost data are provided but the user has the option to change any of the inputs. The model calculates an annualized life-cycle cost for an entire multimodal transportation system alternative. The annualized life-cycle cost can be separated by the various cost categories defined, such as travel time cost, agency cost, and user cost.

Case studies consisted of applying the full-cost model to existing transportation corridors, most of which were already in the process of having potential multimodal transportation system alternative improvements evaluated by the respective MPO and TxDOT transportation policy makers and planning staff.

These case studies included two corridors in the Houston-Galveston Area Council jurisdiction (IH-10-Katy Freeway and US 59), one for the San Angelo MPO on the Houston-Harte corridor, one for the San Antonio MPO on the IH-35 Northeast corridor, and one for the El Paso MPO and the El Paso Sun Metro transit authority on the Patriot Freeway-Downtown/Route 42 corridor.

PRIMARY FINDINGS

Cost Components of a Transportation System

A transportation system is composed of several components:

- guideways (e.g., grade-separated highways, HOV lanes, exclusive busways, surface streets, and rail track);
- vehicles (e.g., autos, buses, and rail cars); and

- control and support infrastructure (e.g., refueling, parking, signal systems, transit stations, and maintenance facilities).

Therefore, the costs of a transportation system involve much more than the public agency's costs associated with, say, building and maintaining highways or with purchasing and maintaining transit vehicles. Figures 1 through 3 outline the elements of the full costs associated with a transportation system from the perspective of three users: private or automobile users, bus users, and rail users.

Initial Capital Cost versus Annualized Life-Cycle Cost

The initial capital cost incurred by a transportation agency for construction of a transportation system improvement is not adequate as a measure of the total cost of the system. Initial capital requirements become a very small part of the picture when the full costs of transportation are evaluated. Even if external costs are disregarded, an annualized life-cycle cost of the system (as against merely identifying the initial capital costs incurred by the agency) provides a much better measure of the true costs of alternative transportation system scenarios.

Travel Time Cost

Travel time cost is a significant component of the total system cost, ranging from 10 percent to 80 percent of the total system cost in our case studies. Given the significance of the travel time cost component, it is useful to elaborate on the estimates made of travel time costs.

Assigning a monetary valuation to travel time involves two basic steps. First, an estimate is made of the annual person-hours of travel on the system. This in turn involves making predictions about the future amount of travel demand on the system and estimating vehicle speed/flow relationships. The travel time estimates made with the algorithms in the MODECOST model begin to increase at an exponential rate at some point when the travel demand exceeds capacity. No attempt was made to restrain the level of demand exceeding capacity. However, it is probably not realistic to assume that traffic volumes on a corridor will grow continuously regardless of the capacity of the corridor.

Second, the monetary value assigned to a unit of travel time will obviously affect the cost of travel time. In our case studies, the unit value of travel time ranged from $5 per hour of total passenger travel time to $7 per hour. In two of the case studies, these values are assumed to represent 30 percent to 80 percent of the gross wage rates of the respective communities. These unit values of time are then merely duplicated in other case studies.

Transit Effectiveness

Results from the case studies also found that the effectiveness of transit components in a transportation system is a function of assumed mode splits. In other words, if transit components of a system are not sufficiently utilized, then they are not as effective at reducing the full cost of the system relative to nontransit system improvement alternatives.

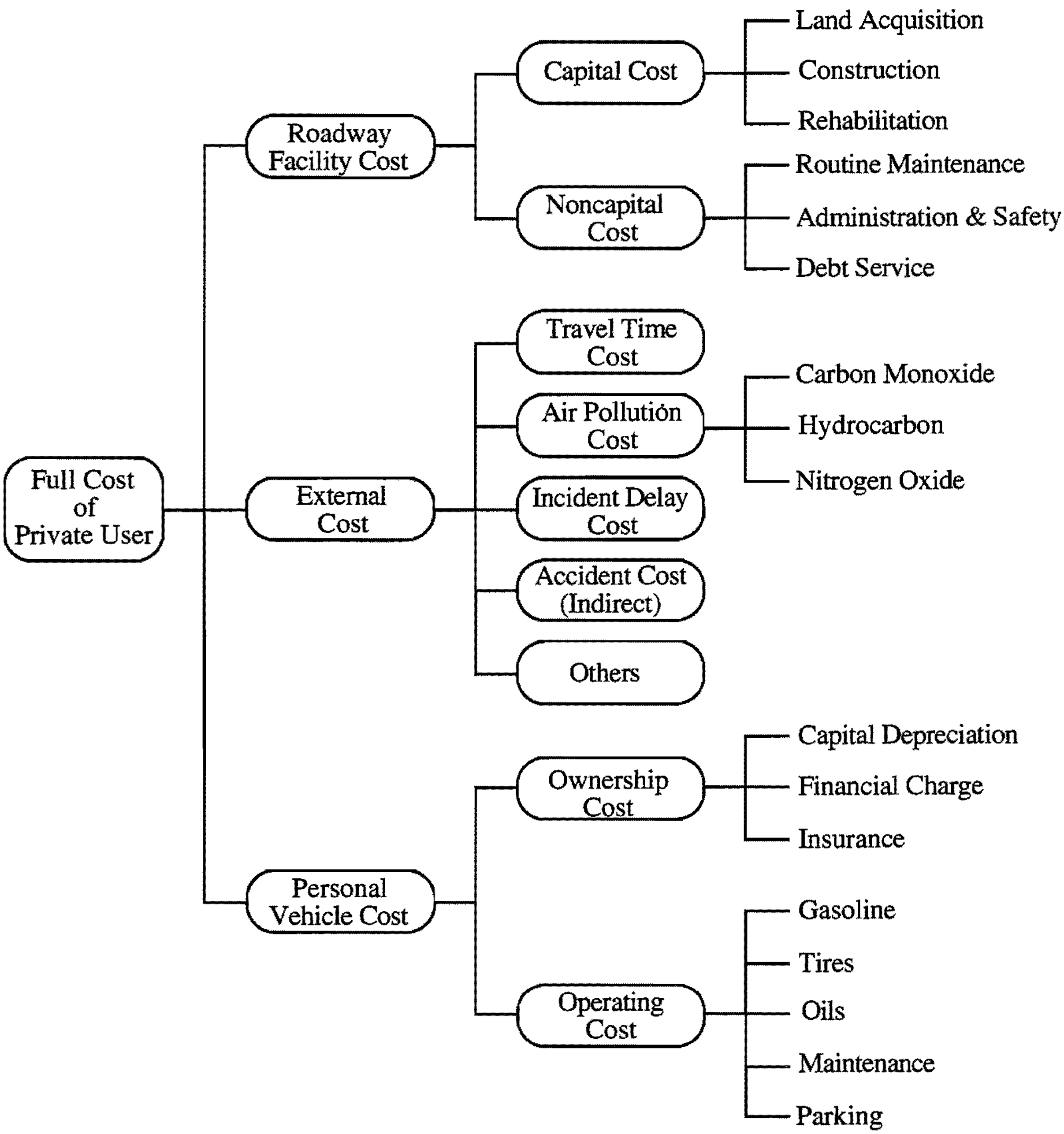

Figure 1. Elements of full costs of private users

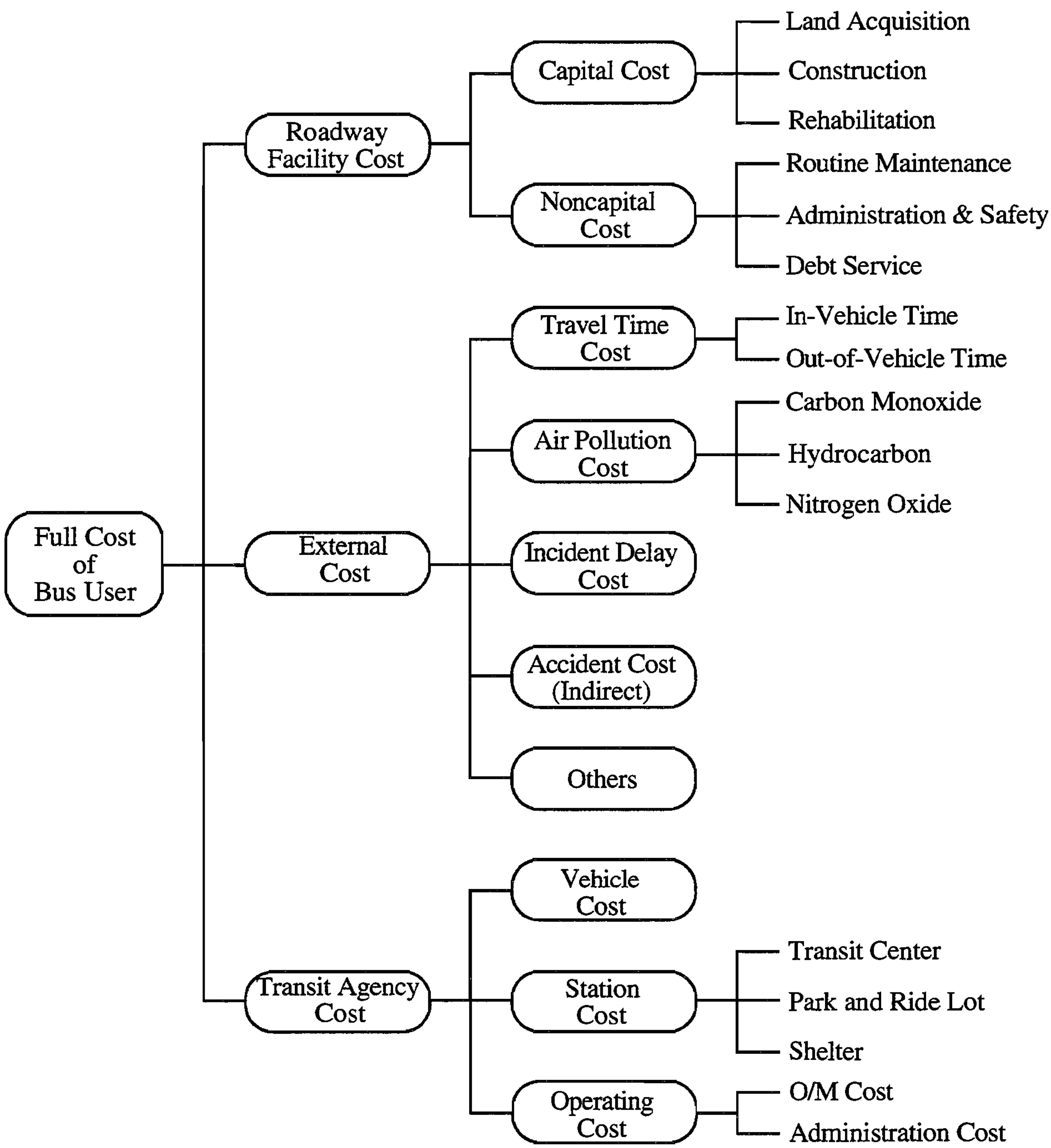

Figure 2. Elements of full costs of bus users

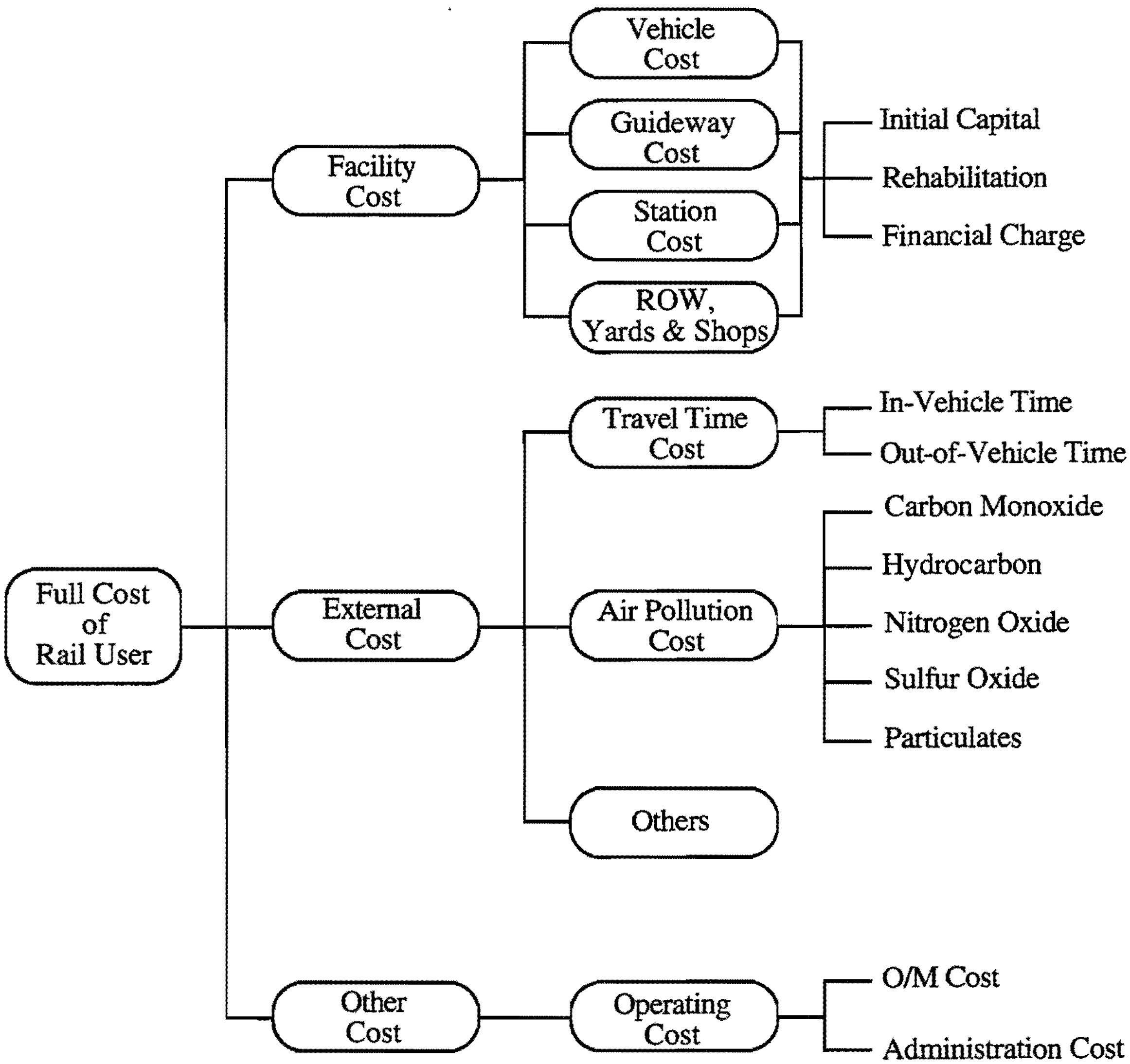

Figure 3. Elements of full costs of rail users

IMPLEMENTATION RECOMMENDATIONS

Recommendations for implementation of the findings of this study are as follows:

1) Do not evaluate the cost of potential transportation system additions or improvements solely based upon the initial capital cost that will be incurred by the Department or any other entity. Evaluate the cost from an annualized life-cycle perspective.

2) Evaluate the full costs of implementing and utilizing a potential transportation system addition or improvement, not just the costs incurred directly by the Department. The full cost includes user costs and external costs, as well as agency costs.
3) Consider potential transportation investments from a multi-user system perspective, not just from the perspective of a particular agency or mode. Various measures of effectiveness (MOEs) of the transportation system might be considered, such as:

- minimizing the full, annualized life-cycle cost of the system;
- minimizing the individual's cost of living;
- maximizing accessibility;
- maximizing mobility;
- maximizing "livability"; and
- other MOEs.

The implementation of transportation system additions and improvements that result from this approach might require the designation of a completely flexible federal or state transportation fund rather than, or in addition to, the current State Highway Fund or the semiflexible federal funding system. Establishment of a flexible Metropolitan Transportation Fund is another potential requirement that would also necessitate legislative action. Further research might be required to look into the transportation investment decision-making process, to quantify various MOEs, and to develop weights for the various MOEs.

CONCLUSION

While the implications of implementing transportation system additions or improvements based upon life-cycle, full-cost analyses have not been fully explored, the approach would seem to be useful in planning an efficient and cost-effective transportation system. Finally, it should be stated that criteria other than efficiency and cost-effectiveness might be required for evaluating a transportation system in order to ensure a minimum level of service to all members of society.

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