USER AND NON-USER BENEFIT ANALYSIS FOR HIGHWAYS

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Foreword

This manual and accompanying CD-ROM provide a valuable resource for people who analyze the benefits and costs of highway projects. These analysts have the difficult and often cumbersome responsibility of performing complex benefit–cost calculations and presenting the results to decision makers, the media, and the public. It has been the practice of the American Association of State Highway and Transportation Officials (AASHTO) to publish materials to support transportation planners in state, regional, and local governments who evaluate highway investments. This manual is the merger of two, related research efforts that should simplify the efforts of these planners.

The first of these efforts, NCHRP Project 02-23, "User Benefit Analysis for Highways," was conducted by the research team of ECONorthwest, in association with Kittelson & Associates, Inc., and Parsons Brinckerhoff, Inc. This effort yielded a major update of the original, 1977 AASHTO user benefit manual. The update incorporated new theory, new measurement methodologies, and new procedural guidance for the measurement of user benefits associated with highway improvements. It also introduced a CD-ROM containing the manual itself, worksheets and a software "Wizard" for guiding the analyst through the user benefit measurement process. The user benefit manual was adopted and published by AASHTO in 2003, and is commonly referred to as the "Red Book".

In response to requests by users of the Red Book, a second research effort was undertaken as an extension of NCHRP Project 02-23. It is entitled "Non-User Benefit Analysis for Highways: A Supplement to AASHTO's User Benefit Analysis for Highways" and was completed in 2007. Its purpose was to add non-user benefit measurement capability to the user-benefit capabilities of the AASHTO Red Book. This project was supported by an agreement between NCHRP and the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the National Academy of Sciences. The research team was lead by ECONorthwest, with assistance from Kittelson & Associates. Inc.

By combining these two, related resources, practitioners now have a single, integrated resource to assist in evaluating highway improvements that incorporates both user and non-user benefits. The theory and methods for estimating the benefits and costs of highway projects are presented in an integrated fashion, first for user benefits and then for non-user benefits. The CD-ROM contains an electronic copy of this manual in Portable Document Format (PDF). It also contains practical materials and resources for conducting and presenting benefit–cost analyses of highway improvements. These resources include the following:

- *Analytical Tools*. An interactive Microsoft Excel "wizard" is provided. This wizard takes the user through a series of dialogs where information about a project is collected and then calculates and presents the results of a benefit–cost analysis in a printable format. A series of Microsoft Excel spreadsheets also are included to help analysts organize data and make calculations to carry out benefit–cost analyses. These spreadsheets are electronic versions of the calculation worksheets in the manual. The analyst can choose to examine just user benefits, non-user benefits or both. In addition, experience with the use of the Wizard by the research team and planners in the field has been exploited to improve the Wizard interface and add more flexibility to characterize highway projects.

- *Presentation Materials.* Microsoft PowerPoint slideshows that can be easily customized are provided to help practitioners prepare presentations about the results of benefit–cost analyses of highway projects. The slideshows complement the guidebook and can be used for presentations to decision-makers, the public, and the media. A library of relevant, royalty-free images for use in presentations and documents is also provided.

- *A Resource Library.* The CD-ROM contains resources to support practitioners as they evaluate the costs and benefits of highway projects. These resources include a glossary of terms used in the manual, a list of transportation organizations and website links where additional data may be found for benefit–cost analyses, and a list of websites that contain useful electronic maps and geographic information systems data.

Preface

This document updates and expands the American Association of State Highway and Transportation Officials (AASHTO) *User Benefit Analysis for Highways*, also known as the Red Book. This AASHTO publication helps state and local transportation planning authorities evaluate the economic benefits of highway improvements. This update incorporates improvements in user-benefit calculation methods and, for the first time, provides guidance for evaluating important non-user impacts of highways. Previous editions of the Red Book provided guidance regarding user benefit measurement only. This update provides a framework for project evaluations that accurately account for both user and non-user benefits.

The preparation of this update was done on behalf of the National Academy of Sciences, National Cooperative Highway Research Program (NCHRP) under project Number 02-23. This project is supported by an agreement between NCHRP and the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the National Academy of Sciences. The prime contractor for the research is ECONorthwest.

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Overview

Preface: Why Use This Manual?

Transportation planners and policy makers are charged with the responsibility of identifying and selecting the projects that deserve implementation. Often, there are competing project designs to serve the same purpose. The project-selection process is complicated further, in most cases, by limited budgets and a host of candidate projects that might benefit the community. In these situations, analytic tools are needed to evaluate the relative merits of each candidate project and ultimately provide a means for allocating resources to that set of projects that will maximize the total benefits. The purpose of this manual is to assist in this process by providing the tools necessary to evaluate the costs and benefits related to transportation improvement projects.

General Purpose

There are many different types of benefits related to transportation improvements. Part One of this manual focuses on *user benefits*, or benefits that are enjoyed by travelers that are directly affected by a transportation improvement. User benefits are determined by travel costs in three distinct areas: travel time costs, operating costs, and accident costs. Taken together, the total of these costs is essentially the price that travelers must pay to travel. When a comparison is made between the costs of traveling and the number of trips taken at each price level, a relationship is determined between the cost of travel and the demand for trips. When all users are aggregated together, the difference between the travel "price" that travelers are required to pay and what they would have been willing to pay is the user benefit affiliated with the trip. Any reduction in travel costs (i.e., trip price), then, will result in a benefit to the traveler. For example, with a cost reduction, users who were already making the trip receive the benefit of making the same trip at a lower cost.

Focusing first on user benefits is appropriate because most of the economic benefits of transportation projects come from the reduction in user costs. When trips in a particular corridor are perceived as costly, perhaps due to long travel times or high accident rates, travelers sacrifice taking some trips in that corridor, and the economic activity associated with those trips is lost. Reducing user costs makes the perceived cost of travel cheaper, and facilitates trip making and the accompanying economic activities. By balancing these accompanying user benefits against project costs, we can determine which projects will provide the optimal level of net benefits to society.

Obviously, however, a project will also impact people other than direct users of the facility. These effects are referred to as *indirect benefits* or *non-user benefits*. Examples of indirect benefits include environmental impacts, effects on urban growth, economic influences, and the distribution of costs and benefits attached with the project. The methods for measuring non-user benefits are different in some ways from the methods used to measure user benefits. To facilitate exposition of those differences, non-user benefit measurement is discussed in Part 2 of this manual, beginning at Chapter 8.

Regardless of whether one examines a project's benefits from the user or non-user perspective, the general framework for measuring project benefits is similar. Project benefit estimation requires that each project being evaluated be compared against some alternative outcome. The alternative outcome could be a "Base Case" or "No-Build Scenario" that maintains current facility conditions into the future. The alternative scenario could also be a different improvement project. In either case, to conduct the project benefit analysis, benefit levels are estimated for two different scenarios. When measuring user benefits, for example, the difference in user costs (that is, the combined effect on user benefits due to changes in travel costs, operating costs, and accident costs) is the impact to the users linked to the project. Since an improvement should result in a *reduction* in these costs, the difference in these cost levels is used to determine the total user benefit of the project. Measurement of non-user benefits also requires a comparison of the project outcome with some alternative outcome. The non-user project benefits are also measured as the difference of the two outcomes.

Complicating Issues

The preceding discussion provides the simplest overview of determining the user benefits connected to the transportation projects. To summarize, this manual provides the tools needed to estimate benefits from changes in travel time costs, operating costs, and accident costs—the factors that directly affect travelers' transportation choices.

Naturally, applying these principles to specific project applications is a much more complicated endeavor in the real world. Complicating issues that need to be addressed include:

- How do you measure the benefits of something that does not yet exist, especially when it interacts in a complicated way with other products or services?

- What do you do if some benefits or costs are not susceptible, at all, to measurements? What if the saving or loss of human life potentially is involved?

- What if the benefits and/or costs play out over a period of time? How should these delays be incorporated in the analysis?

- What if there is uncertainty about the measurements?

- What if many projects have positive net benefits, but budgets are limited? Which projects should be selected for implementation?

- How do you compare projects that have different types of benefits? For example, how do you compare the benefits of one project that improves travel time with another project that reduces accidents or reduces pollution burdens imposed on non-users?

Economists have developed at least partial answers to each of the questions. Much of the challenge in applying benefit–cost analysis in the transportation arena, however, stems from the fact that providing good answers almost always requires specialized information and analysis techniques. This manual provides the analytical tools to help address these questions and allows for the estimation of user benefits for a range of different project types and conditions.

Specific complicating analysis factors are described briefly below. Methods for adapting the user benefit estimation techniques to address these issues are provided in subsequent chapters of this manual.

Different Project Objectives. Some projects, such as the addition of lanes to urban or rural highways, have the objective of improving traffic flows. Those that include installing stop signs or traffic signals at rural intersections have the goal of improving safety and saving lives. Still other maintenance projects, have the purpose of avoiding degradation of the facility and preventing increases in vehicle operating costs, repair or remediation costs, and traveler delays. Although the objectives and types of benefits of these projects are different, they can all be cast in benefit–cost terms and evaluated using the procedures in this manual.

Different Road Types. The same improvement type will have different effects on user benefits depending on the type of road being evaluated. A project that widens a lane, for example, is designed to improve travel times and will have a predictable effect on travel behavior. The magnitude of this effect, however, will depend on a variety of different factors, including whether or not the lane widening occurs on a freeway or an urban street. This manual provides guidance on how to measure the impact of specific improvement types across different street and highway types.

Units of Measure. The elements of project benefits are quantified using different units of measurement, and must be converted to a common, monetary unit of measurement so that they can be compared with project costs. Travel time, for example, is measured in minutes while operating costs are measured in dollars and accident costs might be reported as the number of accidents. This manual provides the methods for converting each benefit component into a common dollar value so they can be aggregated across years, users, and vehicle classes. This conversion also allows for project benefit comparisons across different projects, as the benefits estimated for each project are expressed in common dollar values.

Data Needs. The calculation of project benefits requires a significant amount of information on costs that is specific to the facility and project being evaluated. That is, information is needed for each of the user cost components: travel times, operating costs, accident costs, and costs imposed on non-users. In addition, cost data are needed for both the Base Case scenario and for the scenario where the project is built. In the case of user-benefit calculations, total costs in each of these categories are often estimated as a function of traffic volumes estimated over the life of a project for each of the project scenarios. This manual provides information on where these data can be found and the level of detail needed to estimate user benefits.

Incomplete Data. In practical applications, an analyst is often faced with the problem of missing or incomplete data. For example, the total user benefits associated with a project will be determined in part by the amount of use the facility gets with and without the project being built. This is often determined using traffic volume estimates obtained from a traffic demand model. In some cases, only limited information is available, such as an average annual volume or traffic volumes for a single peak traffic hour or a peak traffic day. This manual shows how this information can be extrapolated to estimate annual traffic volumes, taking into account daily and seasonal fluctuations in travel volumes.

Discounting Costs and Benefits Over Time. Methods for expressing all user benefits in a single dollar value that can be compared across different project types are also provided in this manual. The pattern of costs and benefits over a project's life varies from one project to another, even for alternative projects that are designed to perform the same purpose. For example, improvements projects generally have large capital or investment costs that occur at the start of the project. Operating and maintenance costs are incurred after the construction phase and continue throughout the life of the project. Similarly, benefits of the project accrue to users each year and may increase annually with growth in population and travel demand. This manual shows how these annual variations in multiyear projects can be accommodated so that fair comparisons can be made across projects with different timing of costs and benefits. The procedure is known as the calculation of *present discounted value* of costs and benefits. Discounting procedures allow all project values to be converted to a single dollar value in present value terms, which allows for comparisons across projects.

As this suggests, the estimated user benefits of a project will depend on the methods used to discount future costs and benefits. This manual provides a detailed discussion of the appropriate techniques and discount rates to use for transportation projects for converting benefits to present value terms.

Risk and Uncertainty. Even with the best data, there will be some uncertainty in the estimates of user benefits. Analysis inputs such as traffic volumes, for example, need to be estimated for each year over the life of the project and even the best estimates will still be subject to error. This manual provides tools for adjusting benefit estimates for risk and uncertainty related to future outcomes.

The remainder of this manual expands on this discussion of project benefit analysis. In the first chapter, the manual expands the discussion of the basic economic concepts underlying user benefit calculations. Following this is a discussion of how the user benefit analysis should be applied to specific improvement types. Additional detail is provided in the following sections and worksheets accompanying this manual regarding the calculation of travel time costs, operating costs, and accident costs. In Part One, the focus is on user benefit measurement. In Part Two of the manual, the discussion is extended to include non-user benefits.

Introduction to Benefit Measurement

This manual presents a comprehensive methodology for evaluating the benefits from highway improvements. Highway improvements generate benefits if they reduce the users' travel time, operating costs, the user cost of accidents, or non-user costs. These benefits then can be compared with the cost of developing and operating the highway improvement to determine the basic economic feasibility of the proposed improvement.

In this manual, the broad types of highway improvements considered include:

- Development of new roads.
- Operational improvements to existing roads.
- Safety improvements to existing roadways.
- Highway project-management activities.

Figure 1-1 illustrates the relationship between the user benefit analysis emphasized in this section of the manual and the other areas of benefit investigation that may be pursued. The figure also hints at the kind of technical information or parameters from the user benefit analysis that can be used to assist the measurement of considerations other than user benefits. Items below the dashed line in Figure 1-1 represent the types of considerations that are typically not included in measurement of user benefits alone.

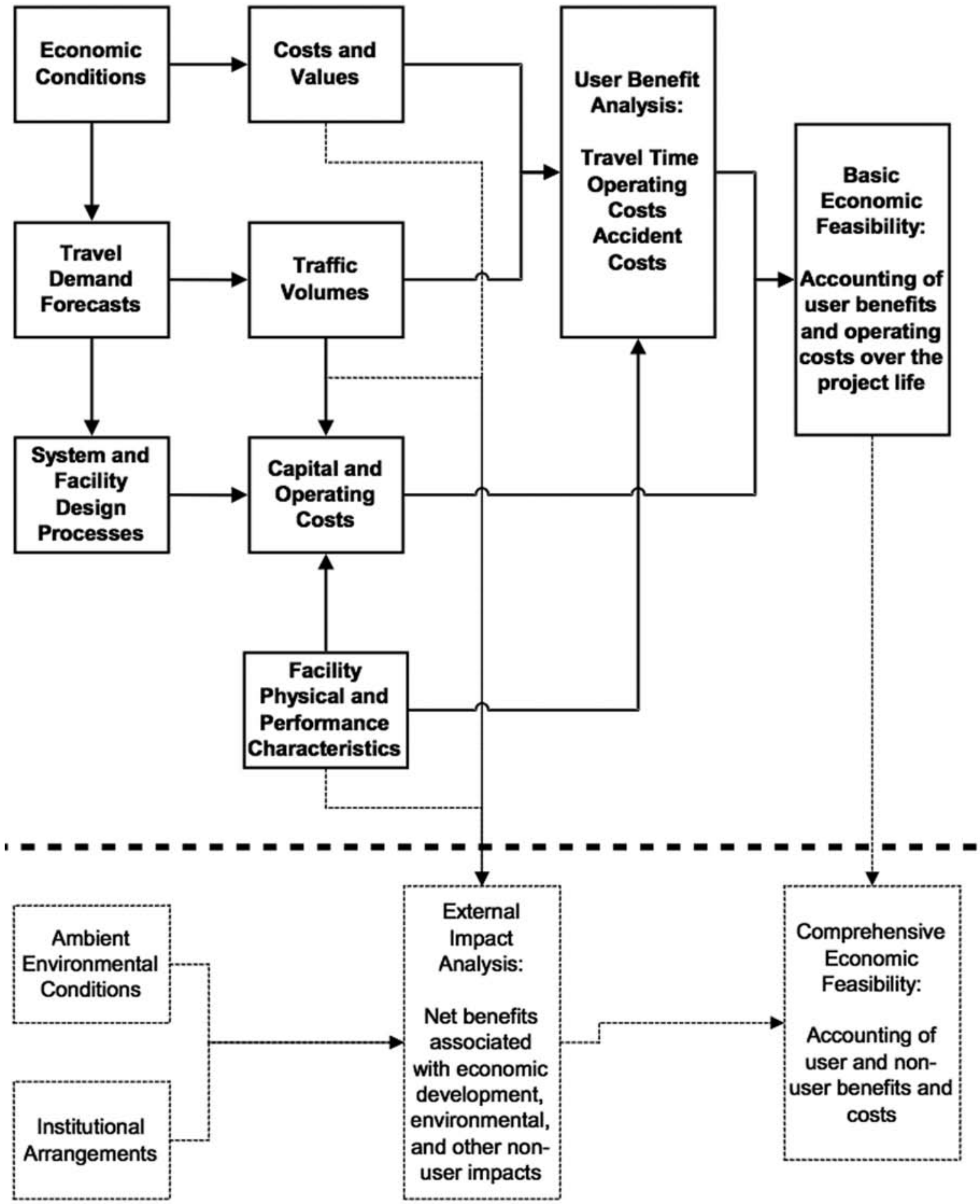

Figure 1-1. Relationship of User Benefit Analysis with Other Analysis Areas

The Workflow Structure of This Manual

This manual has been written with a *workflow* orientation. That is, it is arranged so that the information needed to evaluate a project is developed in an orderly and natural manner. This is achieved by first organizing the analysis by *highway type*, *project type*, and *improvement type*. Then, for each improvement type, there are *analysis modules* that lead the reader through procedures specific to the characteristics of the improvement. The aim is to generate information in a modular form that can easily be joined with other information later in the manual. Analysis of *project management options* and the final *economic analysis* step are the two overarching analyses that bring this modular information together.

This approach requires that the reader have clearly defined the *project* to be analyzed. The manual requires, even for sketch analysis, that the features of the project be carefully defined. The nature of the improvement is what influences the user benefit analysis. The manual is not designed to specify ideal projects, although iterative use of it can help refine and improve a project's specifications.

The reader also is expected to know the *base case* against which the project's virtues are being measured. As a practical matter, it is impossible to measure the total user benefits associated with something as complex as an entire highway system. It is possible, however, to accurately measure the impact of a change to that system, whether it be as significant a change as a brand new freeway, or as modest a change as an improvement in an intersection's signalization timing.

Once the reader brings the project definition to the effort, the manual guides the reader through various categorization and analysis activities.

Highway, Project, and Improvement Types

The manual uses a taxonomy of highway, project, and improvement types to guide the reader to those analytical modules that are relevant for a particular project.

A *highway type* is the broad functional class of road to which the improvements will be made. The highway types recognized in the manual are:

- Arterials, collectors, and local streets.
- Two-lane highways.
- Multilane highways.
- Limited access freeways.

The highway type influences the *improvement types* that typically are involved in an improvement of that type of highway. For example, signalization improvements are not typically associated with limited access highways, except for metering of ramp traffic.

A *project type* is determined by the broad type of service enhancement that the project will be providing:

- Operational enhancements, and
- Safety enhancements.

The project type influences the dimensions of the analysis. Operational enhancements, for example, primarily improve the speed and comfort experienced by the users of the facility. Therefore, analysis of this project type involves considerations of time and operating costs savings. Safety enhancements, on the other hand, primarily affect the accident rate and, consequently, the morbidity, mortality, and property damage common to road usage. Generally, there are different improvement types associated with each of these project types.

Indeed, operational and safety enhancements also, in some cases, have countervailing effects on the analysis. For example, an operational enhancement that speeds up traffic flow may have the effect of increasing the accident rate under some circumstances. Conversely, some safety enhancements, such as signalization and signing, may reduce the effective capacity of a road, and degrade travel times and operating costs. In order to properly incorporate both effects, the analyses must interact accordingly. This is best done by identifying a project's service enhancement type.

The *improvement type* defines the project activity at a level that directs the reader to the appropriate analysis module. For operational improvements, the major improvement types are:

- *Additional Lanes.* This is the conventional method of adding capacity, and can take various forms.
- *A New Road or Highway,* i.e., the addition of a link in the road network that did not previously exist.
- *A New Traffic Control Device or System.* Signals, signs, ramp metering, and roundabouts can be added to existing roads, or incorporated in new roads to enhance effective capacity.
- *Signal Control Systems.* Existing signalization systems can be enhanced to change timing and coordination of traffic flows.
- *Intelligent Transportation System (ITS) Improvements.* These are improvements that allow the road or the user to respond to changing conditions on the road. ITS improvements include such things as variable or incident signage, incident management, and on-board navigation aids.

- *Pricing and Regulatory Policies*. Congestion pricing and designation of lanes as high occupancy toll (HOT) or high occupancy vehicle (HOV) lanes are changes in policies that can affect the performance of a road or a corridor.

Within each of these improvement types, there can be several ***analysis modules*** to choose from. For example, a roundabout and a signalization system are two very different types of traffic control devices for optimizing intersection capacity. There are separate analysis modules for each of these. As indicated in Figure 1-2, the modular analysis process yields the parameters for the evaluation of the project.

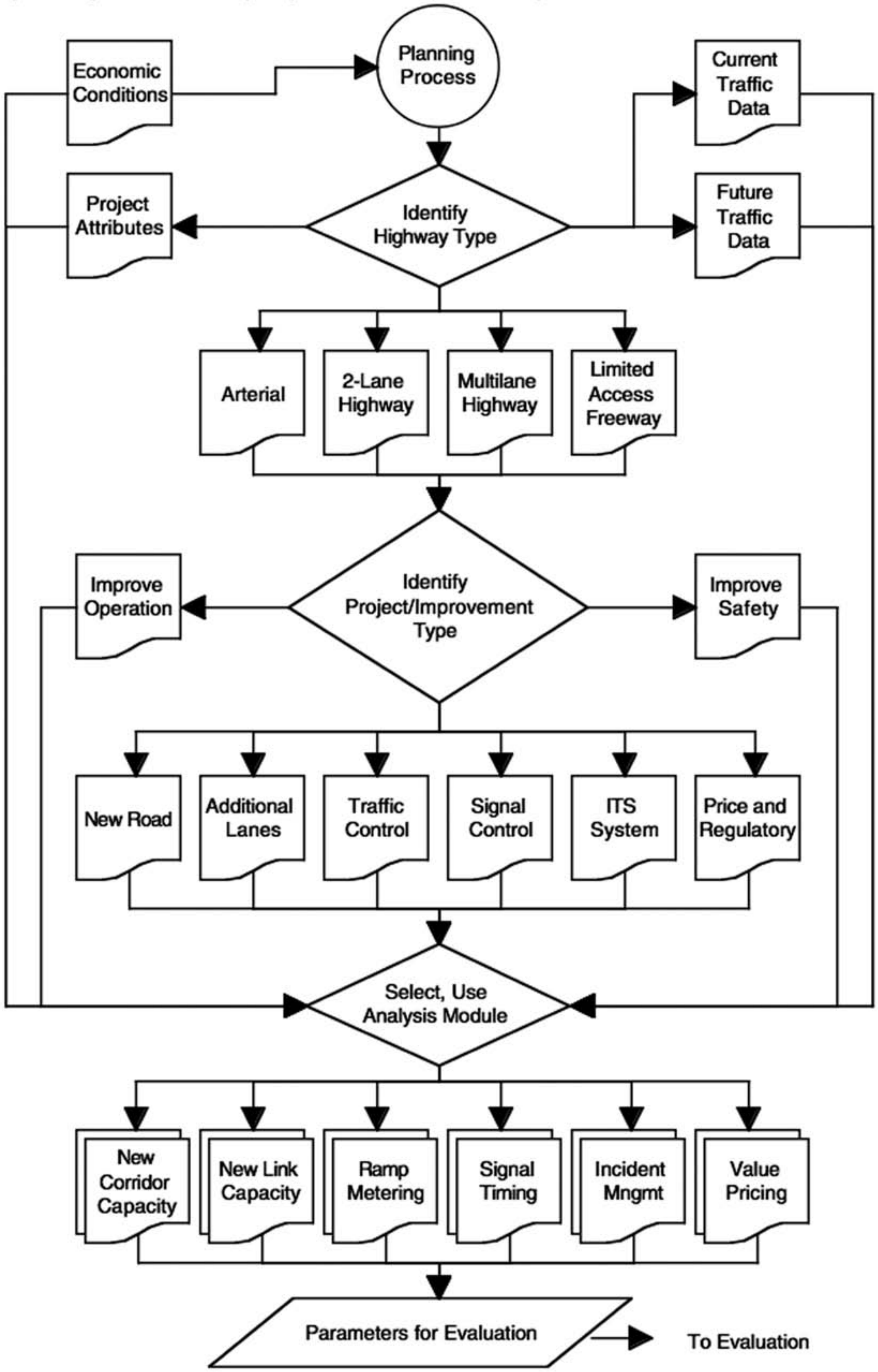

Figure 1-2. The Workflow Path from Project to Evaluation Parameters

Project Management Options

There are two overarching levels of analysis in this manual—i.e., analyses that may apply to a project regardless of its highway, project, or improvement type. The first of these is the analysis of *project management options*.

Although the engineering specifications of a highway project generally determine its performance potential, the extent to which that potential is realized in the most cost-effective manner depends on how the project is managed. Project management affects the *economic feasibility* of a project because it influences project cost, the pace at which the improvements become available, the impact that construction activities have on existing traffic, and so on. In this sense, project management assumptions affect the parameters of the economic feasibility analysis.

Several project management options can be analyzed using this manual:

- *Lane Rental.* Lane rental is a contractor-incentive technique whereby contractors must pay to close lanes while they undertake roadway improvements. Analysis of this option allows planners to determine the tradeoff between speedier completion and higher project cost.

- *Performance Contracting.* A more general technique than lane rental, performance contracting involves providing financial incentives (and, thereby, raising upfront construction costs) for speedier project completion (which, effectively, increases the value of the improvement to users).

- *Public–Private Partnering.* Public agencies that are cash-flow constrained can get beneficial projects built by partnering with private entities; thereby augmenting public funds with private funds. Whether or not such partnering makes sense depends upon the economic value of the improvements and the cost of private funds. Partnering also requires that the private partners have a means of collecting revenues from users upon completion, and thus may require modifying the project characteristics to include a tolling policy, or the analysis of value-capture tax policies.

- *A+B Bidding.* This is one of several incentive/disincentive contracting methods that provide contractors with incentives to complete projects on time and on budget. Under A+B bidding, the bid is evaluated based on both the expected capital costs (A) and the number of days (B) the construction period is expected to last.

The project management evaluation step, and its relationship to the analysis modules and the economic analysis are shown in Figure 1-3.

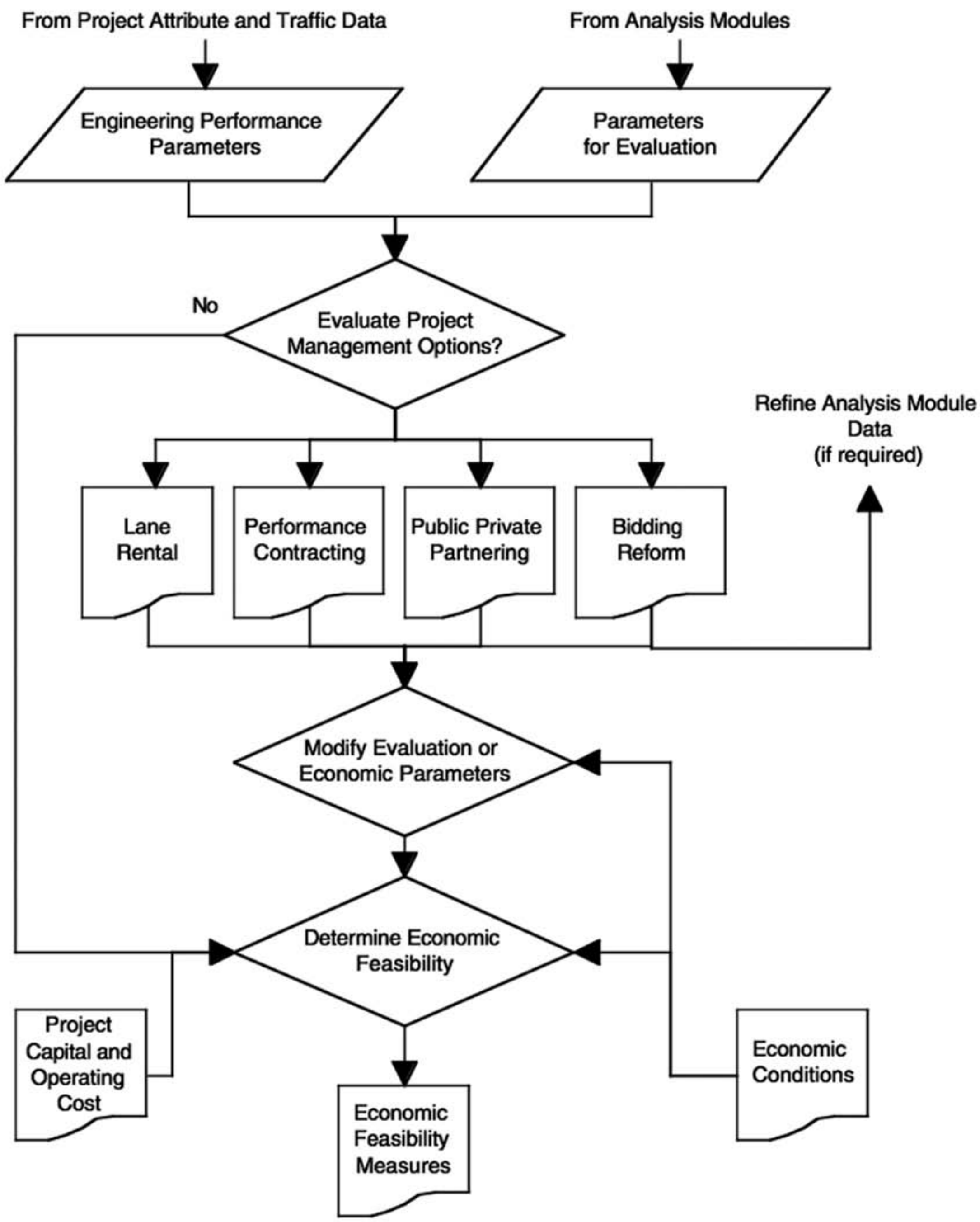

Figure 1-3. The Workflow Path from Evaluation Parameters to Economic Feasibility Measurement

Economic Analysis

The second overarching level of analysis, the *economic analysis* step, is the final, synthesizing step; it aggregates and processes the data developed in the various analysis modules. It makes the determination of the extent to which the proposed project is economically feasible. A project is economically feasible if the value of its user benefits exceeds project costs, properly measured and with recognition of the fact that benefits or costs in the future have a lower present value than benefits or costs nearer in time to the analysis date.

Hence, the goal of the economic analysis is to determine if the present discounted value of user benefits exceeds the present discounted value of project capital and operating costs. Conceptually, this is a simple arithmetic exercise. In order to do this in an orderly manner, however, the following elements of the analysis must be in place:

- Information from the various improvement *analysis modules* must be in a correct and consistent form for aggregation.

- Appropriate assumptions must be made about the project's anticipated life, the appropriate discount and inflation rates, and the values to apply to time, human life, operating costs, and other key cost and benefit factors.

- The pattern of benefits and spending over time must be specified. Methods of interpolating or extrapolating available information must be provided if the analysis done in the improvement modules was not performed for every year of the project's anticipated life.

The economic analysis step provides calculations of benefit–cost measures that are useful both for deciding whether a project should proceed or not, and for ranking the project relative to other, available alternatives. In practice, the benefit–cost indicators generated by using this manual need not be the final word on a project's feasibility. The results of the economic analysis can be used to refine a project's design, timing, or management. In addition, as indicated earlier, the user benefit analysis may be incorporated in a more comprehensive evaluation system.

A Guide to the Chapters of the Manual

The manual has the following chapters:

Chapter 1 provides an introduction to the manual. It discusses the purpose and scope of the manual, and introduces the *workflow* orientation of manual. It also provides a glossary of terms and this summary.

Chapter 2 introduces Part 1 of the manual. It presents the basic concepts and methods used in measuring user benefits. It discusses in detail the requirements of a properly defined project and its base case, and guides the reader through the first steps of the workflow process. The activity in Chapter 2 establishes pointers to the next workflow elements, i.e., the relevant analysis modules and the project management analysis.

Chapter 3 contains the analysis modules for *operational improvements*. The modules accommodate new roads, as well as traffic controls and signal systems. The reader is guided to this chapter by the project classification adopted in Chapter 2. This section also provides pointers to appropriate portions of Chapters 4, 5, and 6 of the manual.

Chapter 4 contains the analysis modules for *safety improvements*. The reader is guided to this chapter by the project classification adopted in Chapter 2 and/or the analysis modules in Chapter 3. This section provides pointers to Chapter 3, as appropriate, and Chapters 5 and 6 of the manual.

Chapter 5 provides modules for analyzing the effects of various project management options. The result of this analysis influences the nature of the economic feasibility analysis performed in Chapter 6.

Chapter 6 contains the procedures for performing economic feasibility analysis using the assembled user benefit measures. The reader is asked to provide key behavioral and financial parameters at this point in the analysis. The reader is also instructed about the motivation and procedures for performing sensitivity analysis.

Chapter 7 presents a survey of the software tools that are available to assist the analyst in measuring user benefits of highway improvements. This manual also provides tools in the form of calculation "wizards" described later.

Chapter 8 introduces Part 2 of this report. Part 2 discusses measurement of non-user benefits for those analysts that wish to extend project benefit measurement to include these effects.

Chapter 9 discusses the measurement of so-called primary non-user benefits. These are non-user benefits that follow more or less directly from the project improvement.

Chapter 10 discusses the measurement of secondary non-user benefits. These are effects that follow indirectly from the primary non-user impacts caused by the project.

Glossary of Terms

Use of this manual involves careful specification and calculation of economic and engineering relationships as well as some of the most commonly used functional classification for streets and highways. A consistent terminology helps keep these various relationships clear in the reader's mind.

Much of the terminology used in the past *Red Book* remains in common professional use. In the 25 years since the *Red Book* was last updated, however, new procedures and relationships have been introduced. As a consequence, this glossary is an amalgam of terminology from earlier editions of the *Red Book* as well as from new research and practice.

Arterial. Signalized streets that serve primarily through traffic and provide access to abutting properties as a secondary function, having signal spacings of 3 km or less.

Average Annual Daily Traffic. The total yearly volume divided by the number of days in the year, commonly abbreviated as AADT. Unless otherwise specified, the terms AADT and ADT (average daily traffic estimated without reference to a year's traffic) will be used synonymously.

Bus. A self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers (at least 16, various legal definitions may differ slightly as to minimum capacity), commonly operated on streets and highways. Smaller capacity road transit vehicles, often without full headroom, are termed vans. This manual does not provide procedures for evaluating transit investments, *per se*. However, the influence of bus transit vehicles on traffic flow and the time- and operating-cost savings associated with bus transit must be accommodated in highway project evaluations.

Capacity. The *Highway Capacity Manual (HCM 2000)* defines capacity as the maximum number of vehicles that have a reasonable expectation of passing over a given section of a lane or a roadway in one direction (or in both directions for a two-lane or a three-lane highway) during a given time period under prevailing roadway and traffic conditions. In the absence of a time modifier, capacity is an hourly volume.

Capital Cost. The total investment required to prepare a highway improvement for service, including engineering design and supervision, right-of-way acquisition, construction, signals and signs, and landscaping.

Centerline Mile. A measure of highway length that counts each mile of a facility regardless of the number of separate lanes. Contrasts with Lane Mile.

Collector. Surface street providing land access and traffic circulation within residential, commercial, and industrial areas.

Congestion. A traffic condition involving interactions of vehicles that results in reduction in speed below the design speed.

Congestion Pricing. A policy of charging for a vehicle's impact on other vehicles' delay.

Design Speed. A speed selected for purposes of design and correlation of those features of a highway, such as curvature, superelevation, and sight distance, on which the safe operation of vehicle depends.

Depreciation, also **Economic Depreciation**. The gradual loss of productive capacity of a piece of capital equipment. Depreciation occurs both as the result of the passage of time, through obsolescence, and as the result of wear-and-tear from use. The term refers to real or economic depreciation, in contrast to tax or accounting depreciation which is an arbitrary proration of capital expenses over time.

Depreciation Rate. The percentage loss in productive capacity per unit time. Typically expressed as a percent per year.

Discount Rate. A percentage figure representing the opportunity cost of capital for an investment, used for converting periodic costs and benefits for a project to present value or to equivalent annual cost.

Equivalent Annual Cost. A uniform annual cost that is equivalent to all disbursements or costs over the analysis period. The present value of equivalent annual cost equals the present value of all such disbursements.

Expressway. See Freeway.

Fixed Cost. A cost that does not vary with activity level or use, but cannot be avoided without abandonment of the facility. Administrative spending is often a fixed cost.

Free Flow. Traffic flow which is unaffected by upstream or downstream conditions. Free-flow speed is the speed expected under free flow conditions.

Freeway. Freeways and expressways are multilane divided highways having a minimum of two lanes for exclusive use of traffic in each direction and full control of access without traffic interruption.

High Occupancy Vehicle. A vehicle that is operated with high passenger occupancies. Variably defined to include carpool vehicles, vans, and transit buses.

High Occupancy Vehicle Lane (HOV lane). A lane that is restricted to use by vehicles with high occupancies.

High Occupancy Toll Lane (HOT lane). A lane that is restricted to use by vehicles that have high occupancies or pay tolls.

Hypercongestion. A traffic condition wherein speed is lower at the given volume than is observed, at the same volume, under other conditions.

Incremental Cost. The net change in dollar costs directly attributable to a given decision or proposal compared with some other alternative, including the existing situation or "do-nothing" alternative. This definition includes any resulting cost reductions (negative costs, or benefits). The only costs that are relevant to a given proposal are incremental future costs, in contrast to sunk costs of the past.

Inflation Rate. The percentage change in the unit value of an element of costs or benefits. Generally expressed as an annual average rate.

K Factor. A factor that relates peak-hour travel to average annual daily traffic (AADT). K is the percentage of AADT represented by two-way traffic volume in the peak hour. Values for K tend to decrease as traffic volume approaches capacity and some peak-hour travel spreads into adjacent "shoulder" hours.

Lane Mile. A measure of highway length that counts each mile of each lane. Contrasts with Centerline Mile.

Long Run. A perspective on cost analysis that assumes flexibility in the capacity of a system like a highway system. In the Long Run, all costs are variable.

Levelized Cost. See Equivalent Annual Cost.

Level of Service (LOS). A qualitative measure of the freedom of a flow of traffic from constraints, interruptions, or other inconveniences, relative to the best possible conditions for a given type of highway facility.

Maintenance Cost. A subset of Operating Cost relating to keeping a highway and its appurtenances in serviceable condition.

Motor Vehicle Running Cost. The mileage-dependent cost of running automobiles, trucks, and other motor vehicles on the highway, including the cost of fuel, tires, engine oil, maintenance, and the value of vehicle wear-and-tear.

Multilane Highways. Roads with four or more lanes, without significant access control features and with low enough adjacent development to permit speed limits of greater than 40 mph and signalization (signals or stop signs) with average spacings of more than one mile.

Occupancy Rate. The number of occupants of a vehicle, expressed as persons per vehicle.

Off-Peak Period. The hours of the day where traffic volumes are lightest on a highway. Contrasts with Peak Period and Shoulder Period.

Operating Cost. The ongoing costs of maintaining and otherwise keeping a road in service. Operating costs include such things as road surface repair, traffic control and lighting expenses, snow removal, cleaning of debris from shoulders, maintenance and replacement of landscaping, restriping, on-going toll collection costs, etc.

Operating Speed. The highest overall safe speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions. (Most HCM 2000 tables and charts give operating speed, but average running speed is more desirable for estimating road user travel time and costs.)

Out-of-Pocket Cost. The incremental cash costs associated with travel.

Ownership Cost. The cost associated with owning, in contrast to operating, a vehicle. Leasing costs, depreciation, insurance premia, and registration fees are examples of ownership costs.

Passenger Car. A motor vehicle with seating capacity up to nine persons, including for capacity and economy study purposes taxicabs, station wagons, and two-axle, four-tired pickups, panels, and light trucks.

Passenger Car Equivalent (PCE). The ratio of a vehicle's influence on a traffic stream to that of a typical passenger automobile. Expressing traffic volumes in terms of PCEs permits analysis of mixed traffic streams.

Peak Period. The hours of the day during which traffic volumes are heaviest on a highway. The length of the Peak Period is variably defined, but by definition, the Peak Period incorporates the Peak Hour. *Contrasts* with Shoulder Period and Off-Peak Period.

Perceived Cost. The subset of costs that are perceived by the user, and to which the user reacts. User costs can exceed perceived costs.

Preservation. A road improvement activity involving significant renovation of the existing roadway without adding to the road's effective capacity.

Project. Any relatively independent component of a proposed highway improvement. By this definition, independent links of a large improvement proposal can be evaluated separately. For a given transportation improvement, all individual contracts or work orders such as grading and draining, pavement, signs, and landscaping can be considered as a single project. Where alternative construction improvements are being considered, separate projects can be defined. However, highly interdependent sections of a highway improvement (such as a bridge and its approach roads) ordinarily should be considered as one project for economy study purposes.

Project Management. Activities relating to the manner in which a project of given specifications is implemented. Staging, financing, ownership, and operation authority are examples of aspects of Project Management.

Present Value (PV). Also termed "Present Worth," it is the present amount that is equivalent to specified amounts of money or time in different time periods, at a given discount rate. Two related considerations underlie the need for computing PV: (1) the fact that money has a time value of capital cost, due to its productiveness and scarcity (see the Definition of Discount rate), and (2) the need in an economy study for comparing or summing outlays or savings of money or time in different time periods.

Primary Non-User Benefit. A impact that falls on non-users and occurs as a direct consequence of a performance feature of the project. For example, emissions reductions that result from improved traffic flow may constitute a non-user benefit.

Project Alternatives are any variations to the basic project plan that (1) involve significantly different costs, (2) result in significantly different levels of service or demand, or (3) incorporate different route locations or other distinctive design features.

Public–Private Partnerships. Legal relationships among public and private entities established for the purpose of jointly providing design, build, or operating services (or some combination).

Ramp. A short segment of roadway serving as a connection between two traffic facilities; usually services flow in one direction only.

Rehabilitation. Rebuilding or restoring an existing facility that is under disrepair or not up to standards.

Residual or Salvage Value. The value of an investment or capital outlay remaining at the end of the study period.

Roundabout. An intersection design that accommodates two or more intersecting roads and permits vehicles to pass through the intersection without signalization or stopping.

Running Speed. The speed over a specified section of highway, being the distance divided by the running time (the time the vehicle is in motion). Average running speed is the same as average speed if there are no stops; otherwise it is higher. For the purposes of this manual, the terms average midblock speed or intersection approach speed are used to denote average running speed in analyzing signalized arterials.

Secondary Non-User Benefit. A project impact that falls on non-users and occurs indirectly as the result of other, primary impacts. The increase in property values near a roadway, for example, is a secondary or indirect effect of access improvements (user benefits) or reduced noise or air pollution (non-user benefits).

Short Run. A perspective on cost analysis that takes as given the capacity of a system like the highway system. Only the utilization of the fixed facility is variable in the Short Run. Contrasts with Long-Run.

Shoulder Period. The hours of the day which are not the Peak Period, but are adjacent to it in time. Variably defined. Contrasts with Peak Period and Off-Peak Period.

Sketch Planning. Sketch planning is a method for developing general estimates of user costs and benefits when more detailed data are not available. For example, sketch planning might rely on annual traffic volumes and simple demand relationships to estimate user benefits when peak hour data and detailed traffic model output are not available. The spreadsheet tool SPASM has been developed for sketch planning analysis.

Social Surplus. Social surplus is analogous to consumer surplus and reflects the total benefit to society resulting from a highway improvement. It is the sum of the individual consumer surplus measures for all persons that will be affected by the project.

Speed. Average Speed (or average overall traffic speed). The summation of distances traveled by all vehicles or a specified class of vehicles over a given section of highway during a specified period of time, divided by the summation of overall travel times.

Study Period (or Analysis Period). The time period over which the stream of benefits and costs is to be evaluated. The final year of construction is designated year 0 (zero), and subsequent years are designated year 1, year 2, etc. Projects involving staged construction that extends over more than four or five years should either be divided into separate projects for the separable stages, or use the final year of construction for the first major stage as year 0, with prior capital outlays being discounted to their present value in year 0.

Taxicab. A passenger automobile that is operated by a professional driver. To account an improvement's benefit to taxicab traffic, the value of operator and passenger time need to be considered.

Transit Vehicle Operating Cost. The cost incurred for operating a bus on a highway facility. Such operating costs include (a) the cost of the drivers' wages and fringe benefits; (b) the cost of vehicle operation, including tires, fuel, and lubricants; (c) the cost of bus maintenance, including labor and parts; (d) costs of insurance, and managerial and administrative labor; and (e) the costs of vehicle rental or depreciation.

Travel Time. The time spent by users traversing a roadway or road network. Conventionally, travel time is expressed in minutes.

Truck. A heavy vehicle engaged primarily in the transport of goods and materials or in the delivery of services other than public transportation.

Two–Lane Highways. Roads with two lanes, speed limits generally greater than 40 mph in both directions, and average signal spacing more than one mile. They may have varying degrees of access control.

User Benefits. The advantages, privileges, or cost reductions that accrue to highway drivers or owners and/or to highway transit users through the use of one highway facility as compared with the use of another. Benefits are generally measured in terms of a decrease in user costs.

User Cost. The costs of travel that are borne by individual users. Highway user costs are the sum of motor vehicle running cost, the value of travel time, and traffic accident cost. Bus transit user costs on a particular highway segment are the fares, the value of travel time, and traffic accident costs.

User Fee or User Charge. A fee charged users for their use of a highway. A Toll is a way of implementing a User Charge.

Value of Time. The opportunity value attributed to one hour of a user's time. This value is different for different types of users and/or trip purposes. It is conventionally expressed in dollars per hour.

Value Pricing. The practice of charging for access to a lane or facility in return for shorter or more reliable travel times. Congestion Pricing is a form of value pricing.

Variable Cost. A cost is variable if it changes with the activity level, such as the number of vehicles, speed, occupancy, etc. Contrasts with the term Fixed Cost.

Variable Pricing. A policy of charging different prices for use of a road at different times or under different conditions. Congestion Pricing is a form of Variable Pricing.

Volume, or **Traffic Volume**. The number of vehicles that use a highway lane or facility. Typically expressed in vehicles or PCEs per hour.

Volume–Capacity Ratio. The ratio of traffic volume to road capacity. Both volume and capacity are expressed in PCE terms.

Volume–Delay Function. A mathematical equation that expresses the relationship among traffic volumes, capacity, and the time required to travel one mile. Different volume-delay functions are attributed to different types of roads.