TCRP
REPORT 61

TRANSIT COOPERATIVE RESEARCH PROGRAM

Sponsored by the Federal Transit Administration

Analyzing the Costs of Operating Small Transit Vehicles

User's Guide

STVe

*(**S**mall **T**ransit **V**ehicle **e**conomics)*

TRANSPORTATION RESEARCH BOARD

NATIONAL RESEARCH COUNCIL

TRANSIT COOPERATIVE RESEARCH PROGRAM

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STVe *(**S**mall **T**ransit **V**ehicle **e**conomics)*

KFH GROUP, INC.
Bethesda, MD
with
LITTLETON C. MACDORMAN
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and
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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
Transportation Research Board

This User's Guide explains the accompanying Small Transit Vehicle economics (***STV*e**) model—a tool designed for transit planners and others making decisions about the purchase of small transit vehicles for different services and operating environments. The computerized ***STV*e** model is based on the principles of engineering economics and allows the user to assess whether it makes economic sense to invest in a particular type of vehicle, based on user-defined inputs. The User's Guide describes how to run the model and interpret its results. The ***STV*e** model and User's Guide will be of interest to transit operators, planners, policy makers, and others concerned with the costs associated with implementing small transit vehicle service in the United States.

Fixed-route transit service has traditionally served medium-to-higher density residential and commercial centers in metropolitan areas. Usually, transit services in such areas are operated most efficiently with standard transit vehicles, because the passenger loads are large. However, much of the recent growth in residential and commercial centers has occurred at lower densities on the fringe or even beyond the fringe of metropolitan areas. Transit services that are appropriate for these areas—feeder, route-deviation, and paratransit services—do not often carry large passenger loads. The same is true of circulator routes in suburban activity centers and fixed-route services in small cities. In order to provide these new transit services in the most economical manner, providers are looking to employ smaller vehicles (i.e., 28 passengers or less). There are many types and sizes of small transit vehicles, a wide range of purchase prices, and a wide range of reported useful lives. It is difficult to make purchase decisions about dissimilar vehicles used in dissimilar types of service. In order to make the best possible vehicle decisions, information is needed about the full range of costs associated with using small transit vehicles.

Under TCRP Project B-14, research was undertaken to develop a practical decision tool, incorporating actual cost data, to assist transit operators, planners, and policy-makers in considering all relevant costs when selecting among small transit vehicles for different service and operating environments. The focus was on the characteristics of capital, operating, and maintenance costs of various types of small vehicles, not on the planning tradeoffs between capacity and frequency.

The research for Project B-14 was conducted in two phases. During Phase I, the researchers began by developing classification schemes for (1) the types of services that might be operated with small vehicles and (2) the types of small vehicles. A basic economic decision-making model, sensitive to the service and vehicle classification schemes, was developed in Phase I. Simultaneously, the team identified and explored other nonfinancial aspects of the decision, a process that continued throughout the study effort. During Phase II, the team collected the data needed to calibrate the model both from national sources and by obtaining actual operating data from systems using smaller vehicles.

To use ***STV*e**, users input certain baseline information to the model software, such as the general type of service for which they intend to use the vehicles, the maximum number of passengers that a vehicle will need to carry at any one time, and basis system cost information (such as mechanic labor rates). Then ***STV*e** uses basic cost input data to perform calculations and provide cost information comparing the different vehicle types, allowing users to see which of the vehicle models is most economical for their purposes.

This User's Guide was developed to accompany the computer software, describe the ***STV*e** model, and explain how to use it. The User's Guide also discusses nonfinancial, nonquantifiable factors that influence the size of vehicles to be purchased. The ***STV*e** model software and User's Guide are distributed together as the research products under TCRP Project B-14.

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ANALYZING THE COSTS OF OPERATING SMALL TRANSIT VEHICLES

User's Guide

STVe (***S**mall **T**ransit **V**ehicle **e**conomics)

A Computerized Tool to Assist Transit Planners Select Among Various Types of Smaller Transit Vehicles

PART **1**

INTRODUCTION AND OBJECTIVE

S**mall **T**ransit **V**ehicle **e**conomics **(**STVe*****)** is an economic model designed for transit planners and others making decisions about the purchase of small transit vehicles. The model assists in the evaluation of different types of smaller vehicles prior to acquisition. The ***STVe*** software program uses Microsoft® EXCEL, which operates in a Windows 95 (or higher version) environment.

In recent years, the vehicle manufacturing industry has introduced many new types of smaller transit vehicles to the market. Unlike standard 40-ft transit buses, however, less similarity exists among these smaller transit vehicles. There are many types and sizes of smaller vehicles with a wide range of prices and life expectancies. Yet, even within this changing environment, transit agencies must consider many factors when deciding what type of smaller vehicle to buy:

- What is the purchase price?
- What is the life expectancy of the vehicle?
- Will the vehicle be able to maneuver in the community given the street network and routing patterns (i.e., what is the turning radius)?
- Is the agency's maintenance facility capable of servicing and maintaining the vehicle?

Some of these questions relate to the *economics* of the decision: does it make sense to invest in the particular vehicle? Other factors are *nonfinancial,* but must be considered in the decision-making process. Both factors are addressed in this User's Guide, but only the economics of the decision are considered in the computer model.

Buying public transit vehicles can be considered a business decision, with the objective of making the best possible use of limited resources. This decision involves determining from an array of available vans and smaller buses, which type of vehicle to purchase and operate that best suits the expected travel needs of a particular community. The model ***STV*e** is based on the principles of engineering economy and, therefore, provides information concerning the projected economic differences of various types of vehicles operating under like conditions during the same time period. The results obtained from the model are probably not precise, because they are based on assumptions and estimates that are subject to error. Nevertheless, using the model will provide more useful information than not using one at all.

Several issues must be recognized about this model:

- As an economic model, ***STV*e** does not consider noneconomic factors, even though these may be as important or more important in the decision-making process as economic (monetary) factors. Quality of ride, enhancement of air cleanliness, low noise levels, and vehicle aesthetics are examples of noneconomic factors. Part 8 of the User's Guide discusses an array of noneconomic factors that should be considered. Depending on your agency's situation or your community's goals and objectives for transit, one or more of the noneconomic factors may be the critical determinant in the selection of the type of vehicle for your community.
- The model is designed to compare the future cost differences of different classes of small transit vehicles from the perspective of the owners of the transit agency, namely, local government(s). This is not to imply that the broader perspectives of state and federal governments cannot be accommodated in using the model, but, rather, that the economic results may differ from those for local government(s).
- The model, in its present form, incorporates most of the key factors that contribute to the cost of owning and operating small transit vehicles, including capital purchase, fuel and tires, and mechanical maintenance labor and parts. The research project that developed the model also considered factors such as vehicle leasing, extending vehicle life through major maintenance overhaul, and maintenance servicing including vehicle cleaning and fueling. However, a lack of suitable quantitative information prevented further consideration of those factors.
- The model does not consider the ancillary costs of vehicle operators, nor questions of whether the selection of larger vehicles will thus require fewer vehicles to accommodate total passenger requirements. Fewer large vehicles would result in lower total vehicle operator labor costs but, of course, decrease service headways. The model assumes that the same number of transit vehicles will be required regardless of the vehicle size.

To use ***STV*e**, you will need to input certain baseline information to the model, such as the general type of service you intend to use the vehicles for and the maximum number of passengers that a vehicle will need to carry at any one time. Once you have provided the model with the input data (or in some cases you may choose the default data), ***STV*e** will perform its calculations and provide cost information comparing the different vehicle types. You will be able to see which of the vehicle types is most economical for your purpose. While ***STV*e** provides information on first-year operating and maintenance costs for each type of vehicle tested, its purpose is to *compare* different vehicle types and calculate which type is more economical, rather than provide specific information on operating and capital costs for specific types of vehicles.

This User's Guide contains nine parts, a glossary, and two appendixes. Following the introduction in Part 1, Part 2 describes related TCRP projects that may be useful as you select and procure vehicles. Part 3 includes instructions on starting ***STV*e**. Next, Part 4 discusses the various types of vehicles recognized by ***STV*e**, and Part 5 includes descriptions of the three types of services adopted for ***STV*e**. Following an overview of ***STV*e**'s economic perspective in Part 6, Part 7 provides detailed instructions on using ***STV*e**. Part 8 includes a discussion of various nonfinancial variables that must be considered when procuring small transit vehicles. Part 9 discusses other financial factors that must be taken into consideration in the economic decision-making process. Finally, Appendix A provides examples using ***STV*e**, and Appendix B gives more detail on the economics model.

PART **2**

RELATED TCRP PROJECTS

STVe is the model produced through the research efforts of TCRP Project B-14, "Analyzing the Costs of Operating Small Transit Vehicles." There are two related TCRP projects that may be relevant to users of ***STVe***. The reports and computer disks developed under the following projects can be obtained from the American Public Transportation Association (APTA).

TCRP Project C-8 developed a model for evaluating the costs of fuel options for transit buses, called **FuelCost 1.0**. While FuelCost 1.0 deals with fuel options for *full-sized* transit vehicles, the model and accompanying Guidebook may be useful tools in the consideration of alternative fuels, even if you are looking only at smaller transit vehicles. This project was published as *TCRP Report 38*.

TCRP Project C-9, "Paratransit Vehicle Specifications and Related Special Maintenance Requirements" developed an automated paratransit vehicle performance specification generating system, called **ParaSPEC**. This system is designed to assist transit agencies or other organizations in the vehicle procurement process.

PART **3**

HOW TO START *STV*e

***STV*e** has been designed to operate on an IBM PC-compatible computer with Microsoft® EXCEL for Windows 95 (or higher versions) and a color monitor. You will need to have 1.4 megabytes free space on your hard drive to install ***STV*e**.

To use ***STV*e**, you need only basic computer skills. Once you have determined that your computer hardware and software meet the requirements described above, insert the ***STV*e** disk into your disk drive and copy ***STV*e** to your computer's hard drive. Then store the original disk in a safe place for future reference. Running ***STV*e** from your hard drive should allow the model to work faster and saving an original version of the model on disk will preserve the default values should they be inadvertently overwritten.

To use ***STV*e**, start up EXCEL and then open the ***STV*e** file. The ***STV*e** EXCEL workbook includes two worksheets: the *Input* sheet and the *Report* sheet. Both data input and report results are described in detail in Part 7 of this Guide.

When using ***STV*e**, print out both the *input* and the *report* results each time you run the model. You can label each version of the model that you run in the ID field. When you are finished with each version, just close the file but **do not save** the file as this would override the model's default values. **If you want to save the model results, you need to save them as a separate file.** (NOTE: If the default values are overridden by mistake, use the original ***STV*e** disk and make a new copy for your hard drive. This is why it is important to store that original disk in a safe place!)

PART **4**

TYPES OF VEHICLES

STVe is designed to assess *smaller transit vehicles*, which have been defined for this project as transit vehicles 30 ft or less in length, but no smaller than a standard-sized van. Low-floor vehicles are included, but rubber-tired trolleys are not. All vehicles considered are Americans with Disabilities Act (ADA)-compliant.

Given the many different types of smaller transit vehicles, a classification scheme has been developed so that the many different types are organized into a standard classification. The classification has grouped vehicles into categories by characteristics that affect capital, operating, and maintenance costs. Fuel type also impacts operating and maintenance costs; however, ***STVe*** has used just one fuel type in each vehicle class as the type of fuel for that class. The availability of field data obtained during the development of the model precluded the model's ability to compare different fuel options within each class of vehicles.

The types of vehicles recognized by ***STVe*** are shown in Table 1, Vehicle Classification. All such vehicles are considered *smaller transit vehicles*, as defined above for ***STVe***. This table presents eight classes of vehicles and provides basic characteristics about the vehicles in the class. (Again, you may want to look at *TCRP Report 38* on **FuelCost 1.0** for more information on alternative fuel options.)

TABLE 1 Vehicle classification

Category 1—Van

Standard vans have front engines with rear-drive. Most vans have a separate body and frame, and they are built on a chassis intended for commercial use. To provide wheelchair accessibility, vans are equipped with a lift or ramp as well as a raised roof with a taller door unit that provides easier entry. With modifications for wheelchair access and securement, total passenger capacity—which includes one wheelchair position—is 10 to 11 passengers. The useful life of a van is projected at 4 years.

Category 2—Van Cutaway, Single Wheel

The chassis and partial cab are obtained from a truck manufacturer and a specialist body builder places a bus body on the chassis, integrating the bus body with the front of the cab, retaining the short hood. With a single wheel in the rear, these vehicles are somewhat lighter and shorter than cutaways described in Category 3. These vehicles have a total passenger capacity of 13. Useful life is considered 4 years.

Category 3G—Van Cutaway, Dual Wheel, Gasoline

Vehicles in this class are similar to those in Category 2; however, there are two wheels on the rear axle. This allows models with longer lengths, which also result in heavier vehicle weights. Total passenger capacity, including ADA-mandated wheelchair positions, is assumed to be 18. While the useful life of vehicles in this category ranges from 4 to 5 years, the model considers the useful life to be 5 years. Vehicles in this category are fueled with gasoline.

Category 3D—Van Cutaway, Dual Wheel, Diesel

These vehicles have basically the same appearance and passenger capacity as those in Category 3G above; however, they are diesel fueled rather than gasoline. Use of diesel affects both maintenance and operations. Again, while the useful life of vehicles in this category ranges from 4 to 5 years, the model considers the useful life to be 5 years.

Category 4—Purpose Built, Front Engine

Vehicles in this category are purpose built, medium-duty. Models within this category vary in price, length, and weight. Total passenger capacity is 22. The useful life of vehicles within this category ranges from 5 to 7 years. The model has assumed a useful life of 6 years.

Category 5—Purpose Built, Rear Engine

These vehicles are similar to those in Category 4; however, they have engines in the back of the bus. Useful life is considered to be 7 years in the model.

Category 6—Medium-Duty, Low-Floor Front Engine

Vehicles in this category are purpose built, medium-duty with a lowered floor to improve accessibility for passengers. In this category, engines are in the front. Total passenger capacity is assumed to be 20. The useful life is 7 years.

Category 7—Heavy-Duty, Low-Floor Front Engine

These are purpose built, heavy-duty, low-floor vehicles, with engines in the front. A major difference with vehicles in this category is life expectancy; the heavy-duty vehicles of Category 7 have a useful life of 12 years.

Category 8—30-Ft, Heavy-Duty Bus

Vehicles in this class are essentially shorter versions of traditional 40-ft transit buses, with a useful life of 12 years. Recently, more 30-ft low-floor buses are coming on the market, but no actual operating data were available to evaluate the low-floor version of the 30-ft bus.

PART **5**

TYPES OF SERVICES

Smaller transit vehicles are used for a wide variety of services. The classification of such services typically includes the following categories: traditional fixed-route; feeder service to rail stations; line haul bus route or other trip generators; activity center circulator (e.g., shuttle service); route deviation; general public paratransit; and specialized (e.g., ADA) paratransit. Such groupings are useful for describing the different operating characteristics of transit service, but are less useful for distinguishing characteristics that affect costs of operating and maintaining the vehicles.

For assessing small transit vehicles, the model recognizes three types of service. This typology is based on that used by the Federal Bus Testing and Research Center in Altoona, Pennsylvania (generally referred to as "Altoona") for evaluating fuel economy of transit vehicles. The three types adopted for ***STV*e** are as follows:

1. **CBD (Central Business District) service** – For evaluating the fuel economy of transit vehicles operating in CBD type service, the Altoona testing uses a distance of 2 miles with seven stops per mile and a top speed of 20 mph. Essentially then, for purposes of ***STV*e**, CBD service is characterized as service with relatively low average speed and frequent stops for passenger boarding and alighting, typically within an urbanized environment.
2. **Arterial service** – Based on Altoona testing, arterial service uses a distance of 2 miles with two stops per mile and a top speed of 40 mph. For ***STV*e**, this is a service environment that is less congested than CBD service, with fewer stops and higher average speeds.
3. **Commuter service** – Altoona tests commuter service over a 4-mile distance, with just one stop and a top speed of 40 mph. For ***STV*e**, this service type has the fewest stops per mile and average speed somewhat higher than that of arterial service.

If your agency operates paratransit service, you will want to consider the characteristics of your service area, clientele, and operating policies that affect average vehicle operating speed. Paratransit is typically characterized as service with few stops, with longer dwell times than fixed-route service and relatively higher speeds in between stops. Among the three service types used by ***STV*e**, *arterial service* might be a good choice.

For purposes of ***STV*e**, service type affects costs as a fuel economy factor. Transit vehicles operating in more urbanized settings with many stops for passenger boardings and alightings will use more fuel per mile than comparable vehicles operating at somewhat higher speeds and with fewer stops per mile.

While other aspects of the operating environment also affect maintenance and operating costs, this first version of the model does not consider such effects because the data needed for model development are not available.

PART **6**

UNDERSTANDING *STV*e'S ECONOMIC PERSPECTIVE

As explained in Part 1, ***STV*e** is based on the principles of engineering economy. It provides information concerning the projected economic differences of various types of vehicles, operating under like conditions during the same time period. This information allows the user to assess whether it makes **economic** sense to invest in a particular type of vehicle. Remember, the "e" in ***STV*e** stands for "economics."

Most investment problems from an economic perspective (including the acquisition and operation of public transit vehicles) involve determining what makes sense in the long run, which is years, not days. For such problems, it is necessary to recognize the *time value of money*. This concept—the time value of money—exists because of *interest*. Because of the existence of interest, a dollar today is worth more than the promise of a dollar next year or sometime later in the future. This is why banks pay you interest when you deposit your money into their accounts. To calculate the fact that money today is worth more than the prospect of that same amount of money in the future, economists use a *discount rate* (also referred to as an interest rate). This practice allows the economic analysis to *discount* future money back to present time, essentially calculating future money's present worth.

By this point in the User's Guide, you may think this discussion is becoming increasingly irrelevant or too esoteric, but please read on, as the *discount rate* can have a significant impact on the results of ***STV*e**.

In the development of ***STV*e**, the researchers determined the most appropriate *discount rate* to use for the model's calculations. The best documented sources on economic analyses and discount rates say there is no single right number because of the many factors affecting its choice,[1] in addition to the imperfection and unpredictability of the economy. "The rate must be chosen as a matter of judgment."[2] The U.S. Congress has weighed in on discounting analysis and rates of return: a Congressional Committee on the topic stated that "depending on the system of weights adopted, this rate is currently in the 8–10 percent range."[3]

Building on the Congressional Committee findings, the default discount rate set for ***STV*e** is 8.5 percent. However, the discount rate can be defined by the user, and it is strongly suggested that you conduct each evaluation of vehicle alternatives using three or more discount rates, for example, 5 percent, 10 percent, and 15 percent. By using several different discount rates for the model's analysis, the effect of the discount rate will be shown. For more guidance on an appropriate discount rate, you may want to

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[1] For example, see "Factors Considered in Setting *I**," Eugene Grant, W. Grant Ireson, and Richard S. Leavenworth, *Principles of Engineering Economy*, 8th ed., John Wiley & Sons, New York (1990), p. 325.

[2] Robley Winfrey and Carl Zellner, "Summary and Evaluation of Economic Consequences of Highway Improvements," *NCHRP Report 122*, Highway Research Board, National Research Council, Washington, DC (1971), p. 35.

[3] U.S. Congress, Joint Economic Committee, Subcommittee on Economy in the Government. Report on the Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis, Government Printing Office, Washington, DC (1968), p. 16. This report is the last known published Congressional committee report on the topic.

refer to OMB Circular A-94,[4] keeping in mind that this circular provides one opinion on what discount rate the Federal Government should use to evaluate its programs.

When you review the results of a model calculation, if the same vehicle class always has the lowest equivalent annual cost using an appropriate range of discount rates, then it is safe to assume that any reasonable discount rate will have little or no effect on your economic decision. If, on the other hand, using the range of interest rates results in more than one vehicle class having the lowest equivalent annual cost, then noneconomic factors should weigh heavily in the selection decision.

For more information on the ***STV*e** economic model and it's internal calculations, see Appendix B.

[4] OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, revised October 29, 1992 [Online] Available: http://library.whitehouse.gov/omb/circulars.

PART **7**

USING *STV*e

To begin running the model, you will need to provide ***STV*e** with specific data so it can run (or you will need to accept the model's default value). Specifically, you will input (or accept the default for):

- Information about the service to be operated with the vehicles,
- Information about the vehicles you are considering, and
- Information about the cost and funding to be used to acquire the vehicles as well as the compensation for mechanics.

Where you have actual data for the model input, it is suggested that you use that data for ***STV*e** rather than using the default value. This will make the resulting output more accurate and useful for your specific decisionmaking.

Figure 1 shows the data input screen for ***STV*e**. You can accept the default values, which are shown in Figure 1, or you can enter your own data. Once you enter input data, hit ENTER. After you have finished inputting data in the input screen, put in an identifying label into the ID field. This could be Version 1, or some other label that will help track the model's output. Once you have provided an ID, print out the input screen. It will print out in two pages.

(NOTE: The input screen shown in Figure 1 shows the default values as set for 1999. A number of the default values will increase each year, based on factors set in the model. Thus, when you use the model in future years, some of the default values will be different than those shown in Figure 1.)

Information about the Service to Be Operated

You need to enter data onto lines 1 through 5 to provide information on the service that the vehicles will operate.

☞ **Line 1:** Enter the abbreviation of the state or U.S. territory where the vehicles will predominately operate. The default is U.S. These data operate as a climate factor, as maintenance costs are affected by the climate of the operating environment.

☞ **Line 2:** Enter the year that you expect to place the vehicles into service. You may enter any year including the current year, up to the Year 2078, after which ***STV*e** will not run.

☞ **Line 3:** Enter an estimate of the average number of *annual total vehicle miles* (revenue miles plus deadhead, service, and training miles) that you project to be accumulated for each candidate vehicle.

☞ **Line 4:** You will need to estimate the percentage of total annual miles or time that the vehicles will operate in the three different service type environments. See Part 5 of this User's Guide for more discussion on service types. The three choices of service types are as follows:

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
***STVe* USER INPUT**

Please provide input in the yellow-highlighted boxes for each of the thirteen (13) information requests or accept the default values as shown. When your input is reasonable or within a range expected by *STVe*, the comment box will respond with "o.k." Comments other than "o.k." are meant to provide guidance and, in most cases, will not prevent program execution. However, unreasonable and misleading report values could result. NOTE: First-time users of *STVe* should read the User's Guide for complete information on the model including user-defined input, default values, and model output.

ABOUT THE SERVICE

1. Provide the two-letter abbreviation of the State or Territory where the candidate vehicles are expected to provide most of their service. — US / o.k.

2. Provide the year that candidate vehicles are expected to be placed into service. — 1999 / o.k.

3. Estimate the average number of annual vehicle miles expected to be incurred by each candidate vehicle. *(Please, no commas.)* — 30,000 / o.k.

4. Estimate the percentage of total annual miles or time that candidate vehicles will be used in the following service areas:

CBD	20.0
Arterial	60.0
Commuter	20.0
Total *(must be equal to 100.0)*	100.0

5. Provide the minimum wheel turning radius (in feet) that candidate vehicles must have in order to negotiate roadway conditions in your service area. — 41.0 / o.k.

ABOUT THE VEHICLE

6. Provide an estimate or accept the default values for the total purchase cost of each candidate vehicle class including a supply of spare parts, maintenance training, and warranty coverage:

1. Van, Gasoline	$30,000
2. Single Wheel Van Cutaway, Gasoline	$36,000
3G. Dual Wheel Van Cutaway, Gasoline	$42,000
3D. Dual Wheel Van Cutaway, Diesel	$48,000
4. Purpose Built, Front Engine, Small Bus, Diesel	$77,500
5. Purpose Built, Rear Engine, Small Bus, Diesel	$120,000
6. Low Floor, Medium Duty, Front Engine Bus, Diesel	$130,000
7. Low Floor, Heavy Duty, Front Engine Bus, Diesel	$200,000
8. Heavy Duty 30' Bus, Diesel	$275,000

7. Please indicate the maximum number of passengers that candidate vehicles must accommodate at one time including the minimum wheelchair positions required by ADA. — 10 / o.k.

ABOUT THE MONEY

8. Provide or accept the default hourly wage rate for mechanics who will maintain your candidate vehicles. — $16.00 / o.k.

9. Provide or accept the default fringe benefit percentage of wages for mechanics who will maintain your candidate vehicles. — 35.00 / o.k.

10. Provide the percentage of purchase cost for candidate vehicles you expect to be funded by your agency and/or local government. — 20.00 / o.k

11. Provide the percentage of candidate vehicle mechanical maintenance expense you expect to be funded by your agency and/or local government. — 20.00 / o.k

12. Provide or accept the default cost per gallon of fuel you expect to pay using candidate vehicles and including any taxes, if appropriate.

Gasoline	$0.685 / o.k.
Diesel	$0.503 / o.k.

13. Provide or accept the default percentage rate of interest for the time value of money. — 8.50 / o.k.

ID: Example   Today's Date: 8/12/99

*Figure 1. Example of **STVe**'s Input screen.*

1. *CBD service,*
2. *Arterial service,* and
3. *Commuter service.*

To run ***STV*e**, you should choose the service type that best matches that of your proposed service.

If your expected operation fits closely with one of the three types used by the model, then you would enter 100 into that service type. It is possible, though, that your operation does not neatly fit into one of the three service types. In this case, assess your agency's service area and operating characteristics, including the average number of stops per mile and typical average speed by time of day or day of week, and then allocate proportions into two or three service types to approximate your agency's service type (the proportions have to add to 100 percent). Remember that ***STV*e** uses service area type as a fuel economy factor and will use that same factor for all the candidate vehicle classes that you select to evaluate, until you change the service type.

For paratransit service, consider the characteristics of your service area, your clientele, and your operating policies that have an impact on your vehicles' operating speeds (e.g., a policy requiring a wait time for passengers at their pick-up locations of 10 minutes will decrease your average speed). Then choose the service type that comes closest to describing your proposed service. For example, if you operate ADA paratransit service in an urbanized environment with limited productivity and long dwell times at stops, you might want to allocate 50 percent to *CBD* and 50 percent to *arterial service* as your service types for ***STV*e**. If you operate ADA service in a suburban environment with less congestion, then 50 percent to *arterial service* and 50 percent to *commuter service* might be appropriate as your service types.

☞ **Line 5:** Enter the minimum turning radius (in feet) that your new vehicles must have so that they can maneuver within the roadways of your service area. If you do not specify a turning radius, the model will use a default, set at 41 ft, which is the largest turning radius of any vehicle class considered by ***STV*e**. This means that the model will not eliminate any vehicle classes based on turning radius, if you accept the model's default. Values greater than the default of 41 ft will accommodate classes of vehicles evaluated by ***STV*e**.

If vehicle maneuverability is an issue for your service area—for example, your vehicles travel on smaller residential streets and private access roads—it is important to realize that the model may eliminate some classes of vehicles based on the turning radius variable. This is because the turning radius set for each vehicle class is the turning radius of the vehicle within the class with the *greatest turning radius*. For certain classes of vehicles, the turning radius of specific vehicles within the class varies considerably. Users are advised to read information on turning radius in Part 8, Nonfinancial Factors to Consider when Selecting Vehicles, and to treat ***STV*e**'s consideration of turning radius as advisory only.

Information about the Vehicles Being Considered

Lines 6 and 7 ask for data about the vehicle types you are considering.

☞ **Line 6:** You may enter an estimate for the total cost necessary to purchase each vehicle type that you are considering, or accept the default values. This total capital cost should include a supply of spare parts, maintenance training, and warranty coverage. To obtain current information on capital costs, consider contacting your state transit association or possibly several transit agencies who have recently purchased new vehicles similar to the type you are considering.

☞ **Line 7:** Enter the number of total passengers (not including any standees) that you expect the vehicles to accommodate at any one time. All vehicles considered by ***STVe*** are ADA compliant, so the total number of passengers set for each vehicle class includes the mandated number of wheelchair positions. Essentially, the model uses the passenger number to screen vehicle classes so that the appropriate vehicle classes are considered. If you tell ***STVe*** that your vehicles must accommodate 20 passengers at one time, the model will not consider vehicles in Categories 1, 2, 3G, 3D, or 5 as such vehicles are designed for smaller passenger capacity. Please note that this data variable is advisory as the same vehicle can be specified to have seating for a range of passengers, depending on the seating configuration and whether additional wheelchair capacity is ordered beyond that required by ADA. But the variable is important in screening the vehicle classes that make sense for your agency based on expected maximum loads.

If you accept the default for number of passengers (set at 10 total passengers), ***STVe*** will not eliminate any vehicle classes based on this variable.

Information about the Money

Lines 8 through 13 require information about mechanic compensation, funding contribution from local sources, the share of maintenance expense that your agency will fund, price of fuel, and the discount rate, which allows the model to calculate the current value of future costs when comparing the vehicle types.

☞ **Line 8**: Enter the hourly wage rate for the mechanics who will maintain your vehicles. These data should be readily available, and use of a current value for your agency is preferable as mechanic wage rates vary across the country. If you do not have a specific wage rate to use, you have two options: (1) accept the default value or (2) use information provided in Table 2 to determine the appropriate mechanic wage rate to use, which provides an average mechanic wage rate calculated by region of the country.

☞ **Line 9:** Enter the fringe benefit rate for the mechanics or accept the default value of 35 percent. If you contract for your maintenance work, total labor costs including fringe benefits would likely be incorporated in the hourly wage rate input into Line 8; in which case, you would enter “0” in Line 9. Do not enter the percentage sign.

☞ **Line 10:** Enter the percentage of vehicle purchase cost that you expect to be funded by your agency (this would include funding from the local governing body) when you purchase the vehicles. This is the local share of capital costs, not the share provided by the state or federal governments. This factor recognizes the fact that decisions about vehicle acquisition may be influenced by the level of funding that is provided by the local agency versus the level provided by federal or other nonlocal sources. When entering the percentage amount in this line, do not enter the percentage sign.

If you do not enter a number in this line, the model will use a default of 20 percent.

☞ **Line 11**: Enter the percentage of vehicle maintenance expense that you expect will be funded with local funding—by your agency and/or local government.

TABLE 2 Average mechanic wage rates (Source: APTA, March 1999)

Geographical Area	Area Population Size: 2 Million and over	500,000 to 1,999,999	250,000 to 499,999	100,000 to 249,999	50,000 to 99,999	Under 50,000	Average
Great Lakes	18.04	17.83	16.12	16.39	14.43	12.49	16.51
Middle Atlantic	21.16	17.56	16.85	15.91	14.91	12.97	17.42
New England	18.97	17.92	18.45	18.52	18.55		18.35
North Central		17.27	14.55	15.00	19.79	18.47	16.37
Pacific	22.32	21.12	19.76	19.24	17.93	18.54	20.55
South Atlantic	14.39	15.67	15.23	14.60	14.20	14.24	15.10
South Central		15.79	13.84	12.80	13.40		14.73
Southwest/Mountain	16.87	16.22	15.50	15.32	18.52		16.07
Non-Continental U.S.		14.64					
Canada	22.66	22.64	25.41		18.19		
Average	19.95	17.48	16.83	16.41	15.92	14.67	

Great Lakes	Middle Atlantic	New England	North Central	Pacific	South Atlantic	South Central	Mountain	Non-Continental
Illinois	Delaware	Connecticut	Iowa	California	Florida	Alabama	Arizona	Alaska
Indiana	Maryland	Massachusetts	Kansas	Oregon	Georgia	Arkansas	Colorado	Hawaii
Michigan	New Jersey	Maine	Minnesota	Washington	North Carolina	Kentucky	Idaho	Puerto Rico
Ohio	New York	New Hampshire	Missouri		South Carolina	Louisiana	Montana	
Wisconsin	Pennsylvania	Rhode Island	North Dakota		Virginia	Mississippi	New Mexico	
Urban areas of Duluth-Superior, Minneapolis, St. Louis and Kentucky suburbs of Cincinnati	D.C.	Vermont	Nebraska			Tennesee	Nevada	
	Virginia suburbs of D.C.		South Dakota			West Virginia	Oklahoma	
							Texas	
							Utah	
							Wyoming	

Among public transit agencies, this percentage will likely vary from 100 percent to 50 percent and in some cases will be 20 percent. Transit agencies receiving Federal Section 5307 or Section 5309 funds (and in some cases a transit agency can receive both) can use federal capital assistance for funding vehicle “preventive maintenance,” which is defined as “all maintenance costs.” This capital funding is generally available at an 80 percent federal share. If your agency uses federal funds in this manner, you will want ***STVe*** to account for that by entering the percentage of maintenance costs that you expect your agency and/or local government to fund.

If you do not enter a number in this line, the model will use a default of 20 percent.

☞ **Line 12**: Enter the price per gallon of fuel—both gasoline and diesel—that you expect to pay when using your vehicles or accept the default values, determined from U.S. Department of Energy sources. The defaults are set as prices without any federal or other taxes, as most public transit agencies are exempt from fuel taxes. If your agency must pay taxes on purchases of gas and/or diesel, make sure to include such costs when you input prices into Line 12.

☞ **Line 13**: Enter the percentage discount rate. This allows the model to calculate the present worth of expenditures in the future. Please see the discussion on discount rates and time value of money in Part 6. Alternatively, you may accept the default rate set at 8.5 percent.

Information Back from *STV*e

Once you have entered the data that ***STVe*** needs to run, click on the worksheet marked *Report*. (Your EXCEL program is probably set for the “automatic calculation” mode but if it is in “manual calculation,” you will need to press the F9 key for the model to run. ***STVe*** operates favorably in the “automatic calculation” mode, so this is preferred.) This worksheet will show you the model output report; see an example in Figure 2. Be sure to print out this page (it will be labeled as page 3 and contain the same label you specified on your input page) and keep it with the two *Input* pages that you printed out previously.

The output report specifies the *total equivalent annual cost* (EAC), as well as the percent EAC difference, which compares the EAC of the vehicle types tested. It is important to remember that when you review the ***STVe*** report, only the differences among vehicle classes are relevant in a comparison.

EAC is calculated by the model in the following way: yearly capital, operating, and maintenance costs are computed for each year of a very long economic analysis period for the vehicle type. These annual costs are then converted to present worth costs using the rate of discount. These costs are then summed for a total present worth cost for the vehicle type during the analysis period, and finally this value is converted to EAC.

Percent EAC difference, in the fourth column of the output report, is the percentage difference between EAC computed for the vehicle type with the lowest EAC and the other vehicle types shown. The vehicle class with the lowest total EAC will show up with “0.0 percent” in the Percent EAC Difference column. It is this percent difference that is particularly relevant in a comparison of the vehicle classes.

The model also provides you with the purchase price (at the year specified that the vehicles will be placed into service), life expectancy, and estimated first-year operating and maintenance costs for each type of vehicle tested. Estimated first-year operating and maintenance costs include the cost of fuel, tires, maintenance labor, and parts

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
***STVe* REPORT**

	Vehicle Class	Year 1999 Purchase Cost	Life Expectancy (years)	Total Equivalent Annual Cost	Percent EAC Difference	Estimated Year 1999 O&M Cost
1.	Van, Gasoline	$30,000	4	$4,429	0.0%	$2,515
2.	Single Wheel Van Cutaway, Gasoline	$36,000	4	$5,471	23.5%	$3,122
3G.	Dual Wheel Van Cutaway, Gasoline	$42,000	5	$6,553	48.0%	$4,219
3D.	Dual Wheel Van Cutaway, Diesel	$48,000	5	$5,344	20.6%	$2,793
4.	Purpose Built, Front Engine, Small Bus, Diesel	$77,500	6	$7,790	75.9%	$4,115
5.	Purpose Built, Rear Engine, Small Bus, Diesel	$120,000	7	$9,464	113.7%	$4,497
6.	Low Floor, Medium Duty, Front Engine Bus, Diesel	$130,000	7	$9,211	108.0%	$3,751
7.	Low Floor, Heavy Duty, Front Engine Bus, Diesel	$200,000	12	$10,972	147.7%	$4,655
8.	Heavy Duty 30' Bus, Diesel	$275,000	12	$15,417	248.1%	$6,683

Note: A response of "Not Available" means that the vehicle class does not meet your requirements for minimum turning radius, maximum passenger capacity, or combinations thereof.

***STVe* Report** is based only on economic factors. Vehicle selection must also consider non-financial factors. Please refer to the User's Guide.

ID: Example

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Figure 2. Example of ***STVe****'s Report screen.*

for the first full year of service. If you have indicated to ***STVe*** that your agency or local government provide only a partial percentage of maintenance costs, *only that percentage* will be reflected in the reported operating and maintenance costs.

Please remember that ***STVe*** is designed to compare the cost differences of different types of smaller transit vehicles over time, not to give you estimates of the costs to operate and maintain different types of smaller vehicles. Where cost differences are small—10 percent or less—you will want to assess noneconomic factors carefully when selecting the appropriate vehicle type for your agency.

Please also remember to consider the many noneconomic factors involved in vehicle selection, which may be as important, or more important than the economic factors.

PART **8**

NONFINANCIAL FACTORS TO CONSIDER WHEN SELECTING VEHICLES

There are important nonfinancial variables that also must be considered in the decision-making process. Qualitative aspects of the decision cannot be incorporated into the model, such as visual impact or ride quality, because such aspects relate to personal or agency judgments not dollars.

This section of the User's Guide identifies and describes nonfinancial factors that should be considered by decision makers when selecting vehicles for a particular service, including:

- Turning radii,
- Ride quality,
- Street vibration,
- Public acceptance,
- Visual impact,
- Route flexibility,
- Legal liability,
- Adequacy of maintenance and storage facilities,
- Training needs, and
- Fleet standardization.

Turning Radii

While the radius of a circle is defined as the distance from the center of that circle to the circumference or bounding surface, the turning radius of a vehicle is a measurement of the radius of the smallest circle a vehicle can navigate (Figure 3 shows turning radius for a typical 40-ft bus). In general, the larger the vehicle, the larger the turning radius and the smaller the vehicle the smaller the turning radius. Some small vehicles with front-wheel drive have larger turning radii than do similar size rear-drive vehicles. The model currently includes a provision for users to specify the required turning radius, which could eliminate some vehicles from consideration.

You need to consider the turning radius of a vehicle, particularly if there is a need to change vehicle direction on a frequent basis. This could include U-turns, right or left turns, or simply the turning of a vehicle due to a road layout, such as a cul-de-sac. While this factor probably affects decisions involving the purchase of a vehicle to be used in demand-responsive service most often, it does come into play when purchasing fixed-route vehicles especially where road networks and layouts require that numerous "tight" turns be made.

The more turning that is required, the more advantageous it would be to select a smaller, more maneuverable vehicle with a shorter turning radius. The tradeoff in doing so is the loss of seating capacity. Conversely, the advantage in selecting a large vehicle is the increased seating capacity, which may result in less maneuverability.

It is important to note that the turning radii of vehicles within the ***STV*e** vehicle classes vary greatly. For example, the turning radii for vehicles in Categories 3G and

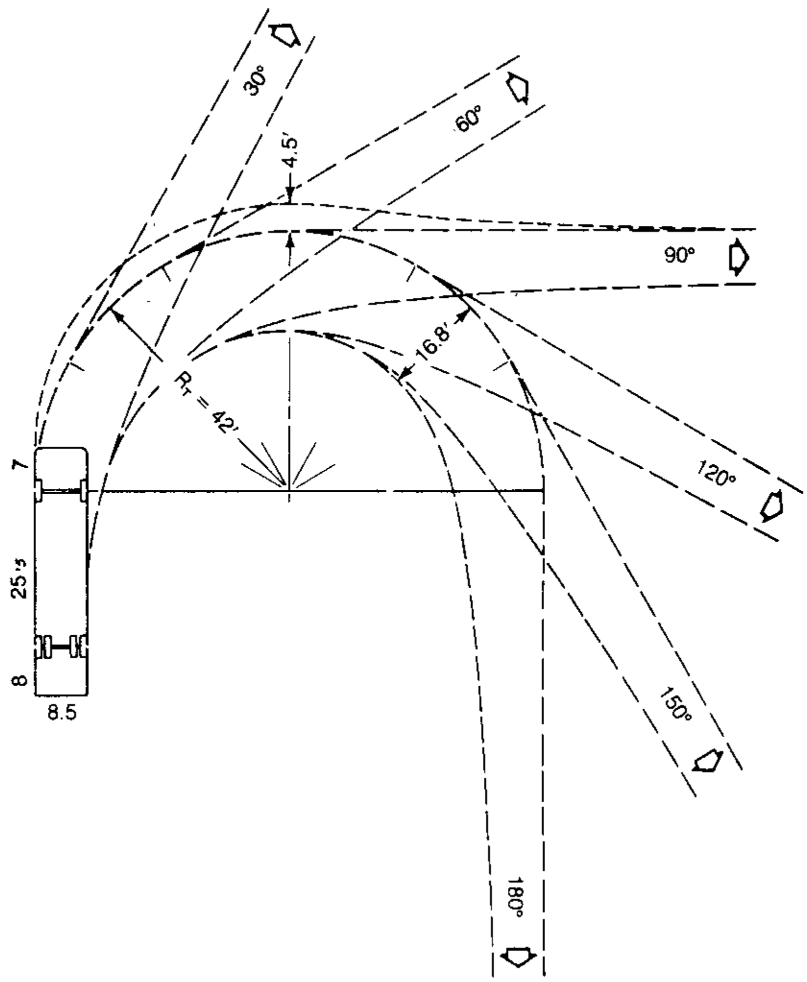

Figure 3. Example of city bus turning radius. (Source: Planning and Design of At-Grade Intersections; Transportation Design Techniques, Inc. Jack E. Leisch & Assoc., Evanston, IL [1981].)

3D vary from 28 ft to 34 ft. In this case, the model uses 34 ft as the minimum required turning radius.

Ride Quality

While the ride quality of a vehicle can be a subjective measure of a passenger's comfort, there are some measurable aspects to ride quality that relate to the types of mechanical equipment used in the manufacturer of a vehicle. These include aspects such as the degree to which a vehicle leans during turns (suspension); the smoothness of acceleration (transmission); bouncing (wheelbase as related to overall length); seat structure and upholstery (cushioned versus hard; plastic versus cloth); seat direction (forward versus side facing); and braking (which can lead to forward pitching of a vehicle).

Because the comfort of some passengers—especially those who are frail and more particularly those making dialysis trips—can be so affected by the ride quality, this factor often affects the selection of vehicles used in demand-responsive type service. The length of trips also affects the need for higher ride quality. As passenger trips to regional transit destinations increase (which they tend to do in more rural areas), the importance of ride quality increases.

In addition to aspects of ride quality such as leaning and bouncing, the type of terrain on which a vehicle is operated can directly affect the decision-making process. If a vehicle is operated in areas with numerous unpaved roads or hilly/mountainous terrain, modifications to a standard vehicle's specifications may be necessary (for example, unimproved roads where ground clearance is a problem may preclude the use of lowered floor vehicles).

In general, heavier vehicles have better ride quality. Longer wheelbase vehicles generally offer a better ride as well. Suspension design is also a major factor in ride quality, with more complex designs such as air springs and independent front suspension generally offering a higher ride quality. The more comfortable passengers are, the happier they are going to be with the service itself.

Street Vibration

One advantage of a smaller, lighter vehicle could be reduced street vibration. Street vibration is a measure of the degree to which a vehicle's motion on a roadway leads to vibration of the road surface and subsequently to surrounding structures whether homes or businesses. As vehicle weight increases, so does the level of street vibration, which occurs because of the vehicle's motion. However, the distance between the roadway and the affected structure directly influences the level of vibration. As this distance increases, the level of vibration decreases, because the ground is capable of absorbing the resulting vibrations.

In addition to vehicle weight, engine type also affects the level of street vibration especially during periods of idle. Diesel engine vehicles tend to be somewhat noisier and the idling leads to vibration of the surrounding ground.

While street vibration can be a nuisance factor to businesses that reside along a vehicle route, it is more of a disturbance in residential areas where a vehicle might be operated early in the morning or late in the evening when residents are sleeping. As such, street vibration affects vehicle selection in terms of the times of day when service operates, the size of a vehicle that is operated on a route, and the type of engine in the vehicle. Additionally, street vibration affects vehicle selection when the distances between the street and surrounding businesses and homes are minimal. If street vibration is a concern and distances are minimal, a smaller and lighter vehicle would be chosen to operate service, provided the vehicle can accommodate peak-hour loads.

However, as vehicles get smaller and lighter, their capacities also are reduced. In choosing a smaller and lighter vehicle to reduce street vibration, the resulting passenger capacity may not meet peak-hour loads. As such, some compromise between the level of street vibration and capacity must be met in the vehicle-selection process.

Public Acceptance

Public acceptance refers to whether or not the general public (including both choice and captive riders as well as nonriders) is accepting of the type of vehicle. Surveys have indicated that the general public is more accepting of smaller, quieter, less obtrusive vehicles. Larger vehicles tend to be noisier, cause more street vibration, and are generally less visually appealing to the general public. However, smaller vehicles such as vans may not be perceived as real "public transit."

Public acceptance can so often dictate where and when vehicles are operated, and it may be one of the most important nonfinancial decision-making factors. In residential areas with narrow streets, it would be more appropriate to select a smaller, lighter vehicle, which has less street vibration associated with it and which may be less obtrusive to the community.

Because larger vehicles tend to be noisier, cause more street vibration, and in general are thought to be more cumbersome, these vehicles tend not to gain the public's acceptance as easily as smaller vehicles. For this reason, it can be more advantageous to use a smaller vehicle in residential areas with narrower streets and to use larger vehicles along major thoroughfares.

Visual Impact

The visual impact of a vehicle refers to the appearance of the vehicle and how it affects both ridership and acceptance of the vehicle by those who do not ride, especially in residential areas served by a particular route. Indications are that choice riders are more likely to ride a bus if it is newer, cleaner, and in general more modern looking. Older transit vehicles with exhaust stains, dents, and misaligned parts tend not to attract choice riders and are less likely to be accepted for use within residential areas. Further, choice riders tend to lean toward smaller vehicles that are generally thought to be "cuter."

On a new route, especially one created to serve choice riders, it might be advantageous from a marketing standpoint to use a vehicle that is newer and possibly smaller, depending on ridership projections. Additionally, if a vehicle is used primarily in residential areas, smaller vehicles that are less obtrusive are likely to be the vehicle of choice.

As with street vibration, the advantages and disadvantages of visual impact in the decision-making process are those aspects dealing with capacity constraints. While a smaller bus may be more attractive to choice riders as well as other passengers, the passenger capacity may not meet peak-hour loads or for that matter off-peak loads. As such, some compromise between the visual impact and capacity must be met in the vehicle-selection process.

Route Flexibility

Route flexibility deals with the issue of swapping vehicles between service types. In other words, can a vehicle be used in fixed-route, demand-responsive, and subscription-type service or is it limited to one service type by capacity constraints; seating configurations; fueling capacity; environmental conditions that affect ground clearance (unpaved roads); vehicle width (narrow roadways) or height (trees) clearance; or by the types of clients that will be transported?

While capacity constraints and environmental conditions are self-explanatory, factors such as seating configurations and the types of clients transported are not. These two factors are intertwined when it comes to route flexibility. Seating configurations affect route flexibility if there is a need to transport large numbers of persons who use wheelchairs. As this number increases, the number of fixed seating locations is likely to diminish and hence result in a lower nonambulatory passenger capacity. Seating configuration is also likely to be affected by the type of service if a wide aisle width is required to accommodate boarding and alighting passengers at the same time (as with fixed-route services).

Because of the constraints resulting from capacity, seating, environmental, and client types, route flexibility affects decisionmaking with regard to much of the interior as well as exterior specifications of a vehicle. If capacity is minimal, the flexibility to put a vehicle on different service types may not exist and if a vehicle has a ground clearance that is minimal or a height clearance that is too extreme, a vehicle may not be operable in areas of unpaved roads or areas with low lying trees.

The principal advantage of obtaining vehicles that can be used on a variety of route or services is that the vehicle fleet size can be minimized. This leads to benefits in other areas including vehicle standardization, maintenance, and training needs. A disadvantage associated with using service flexibility as a factor in the vehicle-selection process is that a chosen vehicle may not meet the needs of all passengers as effectively as one that is designed specifically for them. For example, while the use of flip-down seats allows for the storage of wheelchairs, the flip-down seats are not as comfortable as fixed seats, and while a larger vehicle may accommodate additional passengers, the distance between the vehicle door and the farthest wheelchair securement device may create maneuverability issues for passengers using wheelchairs.

Legal Liability

Legal liability refers to the fiscal responsibility resulting from an accident or injury. In terms of being a nonfinancial aspect of vehicle selection, legal liability comes into play as vehicle capacity increases. Generally, the premiums associated with a vehicle's insurance increases as the capacity increases (the potential risks increase as the number of people on the vehicle increases). Since premiums are very dependent on vehicle size, legal liability, and the resulting insurance costs, they affect the decision-making process.

The primary advantage of choosing a smaller vehicle is the reduction in premiums associated with liability. However, in selecting a smaller vehicle, seating capacity is minimized along with the additional revenue associated with increased ridership.

Adequacy of Maintenance and Storage Facilities

The adequacy of maintenance facilities influences the vehicle-selection process significantly with regard to the size of a vehicle. Maintenance bays and associated equipment including lifts and tools are dependent on the size of a vehicle as larger vehicles require larger bays (height and width), higher capacity lifts, and service pits (if lifts are unavailable). Similarly, a property must have adequate space to store and service larger vehicles if such vehicles are being considered.

As the vehicle size increases, so does the need for larger and more complex maintenance equipment and facilities as well as the need for additional storage and servicing space. In addition to the facilities themselves, as vehicles increase in size, changes in the vehicle specifications, including the use of such features as air brakes, require additions to maintenance equipment and diagnostic tools.

As the adequacy of maintenance facilities improves, so does the ability to maintain larger and more complex vehicles as well as the ability to conduct additional maintenance activities in-house. The performance of maintenance activities in-house leads to more control over quality and quantity of maintenance performed. While improvements to the adequacy of a maintenance facility result in the ability to provide additional maintenance activities, this also leads to more complexity in conducting maintenance activities, which in turn requires improvements in staff training or hiring more experienced staff.

Training Needs

Training needs refer to the time and the cost associated with training drivers and other staff in the operation of vehicles. Because not all vehicles are exactly alike, either in performance or instrumentation, the training requirements on each vehicle vary. While there are basic training requirements for all vehicles, there are differences that affect the level of training including the passenger capacity of the vehicle [Commercial Driver's License (CDL) requirements] and braking systems (air brakes versus conventional braking systems). Other factors that influence training needs include vehicle length and corresponding differences in turning radii, passenger demographics and the level of passenger assistance required to board and alight a vehicle (i.e., low floor versus a conventional vehicle), and the type of service to be provided (fixed-route versus demand-responsive).

Training needs affect the decision process on several levels including operation of the vehicle, passenger assistance, and service type. As the complexity of a vehicle increases, so do the training needs. For instance, while a van may operate much like an automobile, a 30-ft vehicle with air brakes requires an understanding of the turning radius of that vehicle along with an understanding of air brakes and their operation. Similarly, as a transit property adds to the number of different vehicles in its fleet mix, training needs could increase since mechanics and drivers may have to be trained on more than one vehicle type. In addition, CDL training may be needed for drivers if they are moving up in vehicle size.

In general, smaller vehicles will require less training in the actual operation of the vehicle while larger vehicles require more training. However, because smaller vehicles are often used in demand-responsive service, particularly for the elderly and persons with disabilities, a greater level of passenger assistance and other customer-related training are required.

Fleet Standardization

Fleet standardization refers to the selection of vehicles from the same manufacturer or even the same model from the same manufacturer. While this discussion is about the nonfinancial aspects of vehicle selection, standardization can reduce costs through bulk purchase of the vehicles themselves as well as in terms of replacement parts. It further assists in the reduction of costs associated with other factors in the selection process, including operator and maintenance training needs, which can also be standardized as a result of fleet standardization.

The affects on decisionmaking revolve around several factors including the ability of a system to adapt driver and maintenance-training programs to multiple vehicle types, the availability of in-house or private (if not conducted in-house) maintenance providers to adapt to new maintenance requirements, the costs of acquiring additional specialized equipment of diagnostic tools, and the necessity for additional storage.

Fleet standardization focuses on the use of one vehicle type. By procuring only one vehicle type, capital costs associated with the procurement of additional tools and diagnostic equipment as well as training costs can be reduced.

PART **9**

OTHER FINANCIAL FACTORS

Other financial factors that may need to be considered in the economic decision-making process include the issue of extending the life of the vehicle, salvage value, the cost of replacement tires, fuel type, and leasing as opposed to purchasing vehicles. These can have an effect on the costs of operating and maintaining transit vehicles; however, it was not possible to quantify such factors for this first version of ***STV*e**, except for tire cost.

Extended Vehicle Life

For certain transit vehicles, transit agencies may elect to perform a major maintenance overhaul, specifically to increase the life of the particular vehicle. This practice is often done on standard 40-ft transit buses. Typically, the *drive line* of the vehicle is rehabilitated, which includes among other components, the engine and transmission. Given the large capital cost of such larger vehicles, this practice of extending the life can be cost-effective.

Major rebuilds are not, however, generally done on the smaller, shorter-life transit vehicles. Rebuilding is affected by various factors, including the fact that some in the transit industry believe it is not cost-effective; the promulgation of new requirements mandated for transit vehicles (e.g., emissions controls, ADA, etc.); and visual impact (rehabbing a smaller transit vehicle will not update its "look"). However, some larger agencies and major private transportation providers are looking at extending the life of their smaller transit vehicles as they have come to believe it to be cost-effective.

The costs for a major overhaul to extend the vehicle's useful life are considered capital costs and are generally part of the calculation when determining the full cost of the vehicle and its life, usually referred to as "life cycle costing." However, because there are no standards for extending the useful life of smaller transit vehicles, ***STV*e** does not provide the capability to assess the economic impacts of a major maintenance overhaul for the smaller vehicles. It is an option, however, that can influence the decisionmaking when considering the purchase of smaller transit vehicles.

Salvage Value

Salvage value refers to the worth of a vehicle after it has finished its useful life with the transit agency and is being sold or given away. The economic impact of a vehicle's salvage value will be influenced by the market for used vehicles, which will vary community by community. The impact is also likely small and is not considered by ***STV*e**.

Tire Cost

From a maintenance perspective, the cost for tires varies by a number of factors, including how many tires are used by the vehicle, the size of the tires, and the operating environment. The tire operating environment includes factors such as tire inflation, tire inspection, driver training (e.g., how close to the curb do drivers stop with resulting exposure to curbs), and the service area environment (e.g., pavement type, terrain, heat, and number of stops).

Typically, tires used for standard transit vehicles are leased from one of the several large tire manufacturers. These tires, which may be four times larger than tires used for smaller transit vehicles, are very hardy and built to be re-capped a number of times. The tire leasing programs (also called tire mileage or tire casing programs) lease the appropriate size and number of tires to a transit agency for a specified number of miles. Typically, the transit agency pays the tire company a certain amount per tire per mile. Each individual tire will have its own unique identifying number, and the tire leasing company will periodically audit its leased tires at the individual transit agencies to adjust the lease rate to reflect actual operating experience and costs at that particular agency.

Generally, agencies using smaller transit vehicles with smaller tires purchase tires rather than lease them. (Exceptions would be those smaller vehicles using larger tires and the smaller purpose built transit buses, which are really just shorter versions of a standard 40-ft coach). This is done because many transit agencies have found that the cost to re-cap the smaller tires may be as much as buying new tires. Thus, agencies using smaller transit vehicles with smaller tires generally do not use the tire leasing programs.

Fuel Type

When selecting new vehicles, transit planners must consider the type of fuel to be used. In the past, smaller transit vehicles used predominately gasoline or diesel, and these are still common, although alternative fuels are becoming more widely used. Federal and in some cases state regulations governing clean air have prompted the increase in use of alternative fueled transit vehicles.

Fuel economy is a related concern for planners considering new vehicles, as fuel is an ongoing operating expense. Generally, a more powerful engine is less fuel efficient. For an agency using an alternative fuel, fuel economy may be particularly important as the cost of some alternative fuels is considerably higher.

For the current version of ***STV*e**, different fuel options are not included for the categories of smaller vehicles, with the exception of dual-wheel van cutaways where ***STV*e** recognizes both gasoline and diesel versions. If your agency is considering gasoline versus diesel options, you might want to think about several issues:

- Do you have maintenance capability (either in-house or through local garages) to work on the particular type of engine? In some rural areas, there may be few good mechanics with diesel engine experience.
- Is there an adequate supply of diesel fuel?
- What are the relative price differences between the two types?

TCRP Project C-8 developed a model for evaluating the costs of fuel options for transit buses, called **FuelCost 1.0**, which may be useful to you in assessing the potential for your agency to purchase alternative fuel vehicles (see *TCRP Report 38*).

Lease Versus Purchase

Transit agencies may determine that it is more cost effective to lease vehicles than to purchase them outright. For example, if an agency is starting up a new service and wants to gain some operating experience before making a longer-term commitment to vehicle acquisition, it may make sense to lease the vehicles. Or if an agency is using a private contractor to operate the service, it may be advantageous to have the contractor provide the vehicles through a lease arrangement as the contractor will typically be able to acquire the vehicles more quickly.

The use of federal funding for leased vehicles can be cost effective, allowing the agency to leverage federal dollars rather than having to rely on local funds. For transit agencies using Federal Transit Administration (FTA) funds, the costs of leasing vehicles from another entity are eligible for capital assistance, as long as leasing is more cost-effective than purchase. Lease costs are eligible on an 80 percent federal share ratio.

When transit agencies with FTA funds use a contractor to provide vehicles, federal funds can be applied to assist with the capital (e.g., vehicles) used for the contracted service operation. The concept of assisting with capital used is referred to as the "capital cost of contracting." The FTA will provide funding at the 80/20 federal/local share ratio for the capital cost of contracting.

Low-Floor Vehicles

The transit vehicle manufacturing industry introduced low-floor vehicles to improve accessibility and boarding for passengers, particularly the elderly and those with disabilities. Initially, low-floors were available only for standard transit buses, not for smaller vehicles; however, this has changed and smaller transit vehicles can now be obtained with low-floor options, although they tend to be more costly than other models without the low-floor feature.

With the lower floor, clearance has been an issue in some areas where there is snow accumulation or unimproved roads with loose soil, or where the vehicles need to operate on steep driveways and access roads. A recent TCRP report on low-floor vehicles[5] reports that transit agencies surveyed were satisfied with the road clearance attributes of their low-floor buses. One agency did indicate that there were clearance problems for the buses at high at-grade railroad crossings, and several agencies reported that the ramp mechanism protective skid would occasionally ground at steep entrance driveways.

Capacity is more of an issue for the low-floor buses. Generally, the low-floor buses will have fewer seats than a comparable high-floor model. Seat loss is due to the loss of floor space to mount seats with the intrusion of the wheel wells and sometimes to the engine into the passenger area. It has been estimated that the loss is about three seats.

New versions of low-floor buses are designed so that the floor can be lowered and raised by the driver, generally avoiding clearance problems.

[5] King, Rolland D. *TCRP Report 41*, "New Designs and Operating Experiences with Low-Floor Buses," Transportation Research Board, Washington, DC (1998).

GLOSSARY

Americans With Disabilities Act (ADA)-Compliant: With reference to vehicles, it means that the particular vehicle meets the various minimum design standards for transit vehicles as set forth in the ADA regulations.

Axle: A beam with a spindle or spindles about which wheels rotate.

Axle, Single: One axle mounted independently of any other axle.

Axle, Tandem: A two-axle assembly having a means of distributing or transferring weight between the two axles.

Body: The part of the vehicle designed to carry items related to the use of the vehicle rather than the operation of the unit. This does not normally include the cab except when the cab is an integral part of the body as in a panel, suburban, van, or school bus.

Body-On-Chassis: Describes a bus produced by a bus-building manufacturer in which the chassis is acquired from an original equipment manufacturer (OEM), and the bus-building manufacturer builds the entire vehicle body that is mounted on the chassis. This includes the driver area as well as the passenger area. A body-on-chassis vehicle can be what is referred to as “purpose built.”

Chassis: The entire vehicle as produced by the factory (cab, frame, power plant, drive line, suspensions, axles, wheels, and tires) when no body is included.

Cutaway: Describes a bus produced by bus-building manufacturer in which the chassis including the cab is obtained from an original equipment manufacturer and the bus builder builds the passenger compartment on to the chassis.

Discount Rate: The interest rate that is used to convert future investment or costs into their present worth (normally considered today but may also be another point in time). The discount rate is the current popular term for the interest rate representing the value of money.

Equivalent Annual Cost (EAC): The amount of funds disbursed each year during a period of future years that are necessary to pay for the purchase, operating, and maintenance of transit vehicles at the same interest rate during that period. The capital portion of the EAC is similar to making the same monthly payments over a period of time (e.g., 36 months) for the purchase of your automobile (not operating or maintaining) at an interest rate established by the lender (e.g., the bank).

Forward Control: (1) A configuration in which more than half of the engine length is rearward of the foremost point of the windshield base and the steering wheel hub is in the forward quarter of the vehicle length. (2) Vehicle with driver controls (pedals, steering wheel, instruments) located as far forward as possible. Supplied with or without body, the controls are stationary mounted as opposed to the special mountings of tilt cab models.

Front-Wheel Drive: Drive system that transmits power through the front wheels; same as front drive.

Gross Vehicle Weight: Actual weight of entire vehicle including all equipment, fuel, body, payload, driver, etc.

Gross Vehicle Weight Rating: The value specified by the manufacturer as the loaded weight of a single vehicle.

Low-Floor Bus: A bus which, between doors 1 and 2, has a vehicle floor sufficiently low and level enough to remove the need for steps in the aisle both between these doors and in the vicinity of the doors. Passengers in wheelchairs and other wheeled mobility devices enter by ramp rather than lift.

Operating and Maintenance (O&M) Costs: As used by ***STVe*** includes the cost of fuel, tires, and mechanical maintenance labor and parts. If your agency received financial assistance from other than local governments for mechanical maintenance, the amount of that assistance is not included in the operating and maintenance costs shown in the ***STVe*** Report.

Present Worth: The value (or cost) of the funds disbursed during a period of years that are necessary to pay for the purchase, operating, and maintenance of transit vehicles considering the same interest rate during that future period. For example, if you disbursed $100 annually for 10 years, the simple total of that amount would be $1,000. But if the interest rate for borrowing or lending money was 10 percent during that period, the present worth of the $1,000 that was disbursed in 10 annual payments of $100 is only $614.40. This is because a dollar paid today is worth more to the lender then if a dollar was paid at some later date. If your payment is made sooner rather than later, the lender can earn more because of the compound effect of interest. Money has a time value; therefore, the present worth of future dollars is said to be “discounted” using the compound effect of an interest rate.

Rear-Wheel Drive: Drive train design that applies power through the rear wheels only. A rear-wheel drive vehicle may be front engine, mid-engine, or rear engine.

Rehabilitation: The rebuilding of the vehicle to its original specifications which may include some new components, but has less emphasis on structural restoration as is done with remanufacturing.

Remanufacture: The structural restoration of the vehicle in addition to installation of new or rebuilt major components (e.g., engine, transmission) to extend the useful life.

Turning Diameter: Twice the turning radius.

Turning Diameter—Curb-to-Curb: The diameter of the smallest circle within which the vehicle will clear a curb 150 mm high, while the vehicle is executing its sharpest practicable turn.

Turning Diameter—Wall-to-Wall: The diameter of the smallest circle that will enclose the outermost points of projection of the vehicle while executing its sharpest practicable turn.

Turning Radius: The distance from the turning center to the center of tire contact with the road of the wheel describing the largest circle, while the vehicle is executing its sharpest practicable turn (usually to the outside front wheel). See Figure 3.

Wheelbase: Distance from the center of the front wheel to the center of the rear wheel on the same side of the vehicle.

APPENDIX A

Examples Using *STV*e

SCENARIO A—EVERSERVE TRANSIT SYSTEM

Everserve Transit System (ETS) is located in Everytown, UT (a city of 250,000 people). The ETS currently operates standard size (40-ft) transit vehicles on fixed routes. The ETS will start a new commuter service in 2000 that operates from the outlying rural/suburban part of its service area into the city. The service is expected to operate about 27,500 miles annually. The vehicle loads anticipated do not warrant use of a large transit coach—the system expects about 19 passengers per run. The system's planners are interested in understanding which size vehicle would be most economical to purchase and operate.

The new vehicles would be purchased with 80 percent federal funds, 10 percent state funds, and 10 percent local funds. Currently the system maintains vehicles in-house and pays its mechanics an average of $14.85 per hour with a 35.3 percent fringe benefit rate. The system's maintenance expenses are "capitalized" and cover 80 percent through its federal grant. Fuel currently costs $.73 per gallon for gas and $.64 per gallon for diesel fuel (the ETS does not pay fuel taxes). The estimated interest rate is 10 percent.

Scenario A: Figure A-1 presents ***STV*e**'s User Input screens. Scenario A: Figure A-2 presents ***STV*e**'s Output Report for this run. As shown, five vehicles have the capacity to meet Everserve's needs. The vehicles with the lowest equivalent annual cost (EAC) are the ***Purpose Built, Front Engine, Small Buses*** (Category 4). However, the ***Low Floor, Medium Duty Front Engine Buses*** (Category 6) were only 6.3 percent more in EAC and also should be considered (other nonfinancial factors also should be weighed).

SCENARIO B—MOUNTAIN TRANSPORTATION SERVICES, INC.

Mountain Transportation Services, Inc. (MOUNTS), a private, nonprofit agency, operates fixed routes (with deviations) in rural areas of Vermont with 10,000 persons over a service area of 2,000 mi. MOUNTS currently operates vans, but is considering purchasing some larger vehicles because the service is growing and there are sometimes over 15 passengers on the vehicles. Each vehicle operates 35,000 miles annually. The system's planners are interested in understanding which size vehicle would be most economical to purchase and operate.

The new vehicles would be purchased with 100 percent agency funds. Currently, the system contracts for maintenance at an hourly rate of $35.00 (which includes fringe benefits). The system's maintenance expenses are covered 100 percent with agency funds. Fuel currently costs $1.00 per gallon for gas and $.80 per gallon for diesel fuel (the MOUNTS does pay fuel taxes). The estimated interest rate is 15 percent.

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
STVe USER INPUT

Please provide input in the yellow-highlighted boxes for each of the thirteen (13) information requests or accept the default values as shown. When your input is reasonable or within a range expected by *STVe*, the comment box will respond with "o.k." Comments other than "o.k." are meant to provide guidance and, in most cases, will not prevent program execution. However, unreasonable and misleading report values could result. NOTE: First-time users of *STVe* should read the User's Guide for complete information on the model including user-defined input, default values, and model output.

ABOUT THE SERVICE

1. Provide the two-letter abbreviation of the State or Territory where the candidate vehicles are expected to provide most of their service.

UT
o.k.

2. Provide the year that candidate vehicles are expected to be placed into service.

2000
o.k.

3. Estimate the average number of annual vehicle miles expected to be incurred by each candidate vehicle. *(Please, no commas.)*

27,500
o.k.

4. Estimate the percentage of total annual miles or time that candidate vehicles will be used in the following service areas:

CBD	30.0
Arterial	70.0
Commuter	0.0
Total *(must be equal to 100.0)*	100.0

5. Provide the minimum wheel turning radius (in feet) that candidate vehicles must have in order to negotiate roadway conditions in your service area.

41.0
o.k.

ABOUT THE VEHICLE

6. Provide an estimate or accept the default values for the total purchase cost of each candidate vehicle class including a supply of spare parts, maintenance training, and warranty coverage:

1. Van, Gasoline	$30,900
2. Single Wheel Van Cutaway, Gasoline	$37,080
3G. Dual Wheel Van Cutaway, Gasoline	$43,260
3D. Dual Wheel Van Cutaway, Diesel	$49,440
4. Purpose Built, Front Engine, Small Bus, Diesel	$79,825
5. Purpose Built, Rear Engine, Small Bus, Diesel	$123,600
6. Low Floor, Medium Duty, Front Engine Bus, Diesel	$133,900
7. Low Floor, Heavy Duty, Front Engine Bus, Diesel	$206,000
8. Heavy Duty 30' Bus, Diesel	$283,250

7. **Please indicate the maximum number of passengers that candidate vehicles must accommodate at one time including the minimum wheelchair positions required by ADA.**

19
o.k.

Scenario A: Figure A-1.

ABOUT THE MONEY

8.	Provide or accept the default hourly wage rate for mechanics who will maintain your candidate vehicles.	$14.85 o.k.
9.	Provide or accept the default fringe benefit percentage of wages for mechanics who will maintain your candidate vehicles.	35.30 o.k.
10.	Provide the percentage of purchase cost for candidate vehicles you expect to be funded by your agency and/or local government.	10.00 o.k
11.	Provide the percentage of candidate vehicle mechanical maintenance expense you expect to be funded by your agency and/or local government.	20.00 o.k
12.	Provide or accept the default cost per gallon of fuel you expect to pay using candidate vehicles and including any taxes, if appropriate. Gasoline Diesel	 $0.730 o.k. $0.640 o.k.
13.	Provide or accept the default percentage rate of interest for the time value of money.	10.00 o.k.

ID: Everserve Transit   Today's Date: 8/16/99

Figure A-1. (Continued).

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
***STVe* REPORT**

	Vehicle Class	Year 2000 Purchase Cost	Life Expectancy (years)	Total Equivalent Annual Cost	Percent EAC Difference	Estimated Year 2000 O&M Cost
1.	Van, Gasoline	$30,900	4	Not Available	Not Available	Not Available
2.	Single Wheel Van Cutaway, Gasoline	$37,080	4	Not Available	Not Available	Not Available
3G.	Dual Wheel Van Cutaway, Gasoline	$43,260	5	Not Available	Not Available	Not Available
3D.	Dual Wheel Van Cutaway, Diesel	$49,440	5	Not Available	Not Available	Not Available
4.	Purpose Built, Front Engine, Small Bus, Diesel	$79,825	6	$6,860	0.0%	$4,790
5.	Purpose Built, Rear Engine, Small Bus, Diesel	$123,600	7	$8,123	18.4%	$5,341
6.	Low Floor, Medium Duty, Front Engine Bus, Diesel	$133,900	7	$7,293	6.3%	$4,212
7.	Low Floor, Heavy Duty, Front Engine Bus, Diesel	$206,000	12	$9,144	33.3%	$5,364
8.	Heavy Duty 30' Bus, Diesel	$283,250	12	$12,812	86.7%	$7,589

Note: A response of "Not Available" means that the vehicle class does not meet your requirements for minimum turning radius, maximum passenger capacity, or combinations thereof.

***STVe* Report** is based only on economic factors. Vehicle selection must also consider non-financial factors. Please refer to the User's Guide.

ID: Everserve Transit   Today's Date: 8/16/99

Scenario A: Figure A-2.

Scenario B: Figure B-1 presents ***STVe***'s User Input screens and Scenario B: Figure B-2 presents ***STVe***'s Output Report for this run. As shown, seven vehicles have the capacity to meet MOUNTS needs. The vehicles with the lowest equivalent annual cost (EAC) are the ***Diesel Duel Wheel Van Cutaways*** (Category 3D). The same vehicle with a gas engine (Category 3G) might also be considered, especially if the other agency vehicles are gas powered, since this category is only 10 percent more in EAC. As always, other nonfinancial factors should also be considered.

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
***STVe* USER INPUT**

Please provide input in the yellow-highlighted boxes for each of the thirteen (13) information requests or accept the default values as shown. When your input is reasonable or within a range expected by *STVe*, the comment box will respond with "o.k." Comments other than "o.k." are meant to provide guidance and, in most cases, will not prevent program execution. However, unreasonable and misleading report values could result. NOTE: First-time users of *STVe* should read the User's Guide for complete information on the model including user-defined input, default values, and model output.

ABOUT THE SERVICE

1. Provide the two-letter abbreviation of the State or Territory where the candidate vehicles are expected to provide most of their service.

VT
o.k.

2. Provide the year that candidate vehicles are expected to be placed into service.

2000
o.k.

3. Estimate the average number of annual vehicle miles expected to be incurred by each candidate vehicle. *(Please, no commas.)*

35,000
o.k.

4. Estimate the percentage of total annual miles or time that candidate vehicles will be used in the following service areas:

CBD	0.0
Arterial	0.0
Commuter	100.0
Total *(must be equal to 100.0)*	100.0

5. Provide the minimum wheel turning radius (in feet) that candidate vehicles must have in order to negotiate roadway conditions in your service area.

41.0
o.k.

ABOUT THE VEHICLE

6. Provide an estimate or accept the default values for the total purchase cost of each candidate vehicle class including a supply of spare parts, maintenance training, and warranty coverage:

1. Van, Gasoline	$30,900
2. Single Wheel Van Cutaway, Gasoline	$37,080
3G. Dual Wheel Van Cutaway, Gasoline	$43,260
3D. Dual Wheel Van Cutaway, Diesel	$49,440
4. Purpose Built, Front Engine, Small Bus, Diesel	$79,825
5. Purpose Built, Rear Engine, Small Bus, Diesel	$123,600
6. Low Floor, Medium Duty, Front Engine Bus, Diesel	$133,900
7. Low Floor, Heavy Duty, Front Engine Bus, Diesel	$206,000
8. Heavy Duty 30' Bus, Diesel	$283,250

Scenario B: Figure B-1.

7. Please indicate the maximum number of passengers that candidate vehicles <u>must</u> accommodate at one time including the minimum wheelchair positions required by ADA.

15
o.k.

ABOUT THE MONEY

8. Provide or accept the default hourly wage rate for mechanics who will maintain your candidate vehicles.

$35.00
Get me a job!

9. Provide or accept the default fringe benefit percentage of wages for mechanics who will maintain your candidate vehicles.

0.00
Are you sure?

10. Provide the percentage of purchase cost for candidate vehicles you expect to be funded by your agency and/or local government.

100.00
o.k

11. Provide the percentage of candidate vehicle mechanical maintenance expense you expect to be funded by your agency and/or local government.

100.00
o.k

12. Provide or accept the default cost per gallon of fuel you expect to pay using candidate vehicles and including any taxes, if appropriate.

Gasoline	$1.000
	o.k.
Diesel	$0.800
	o.k.

13. Provide or accept the default percentage rate of interest for the time value of money.

15.00
o.k.

ID: MOUNTS

Today's Date: 8/16/99

Figure B-1. (Continued).

TCRP PROJECT B-14
ECONOMIC COST ANALYSIS OF SMALL TRANSIT VEHICLES
***STVe* REPORT**

	Vehicle Class	Year 2000 Purchase Cost	Life Expectancy (years)	Total Equivalent Annual Cost	Percent EAC Difference	Estimated Year 2000 O&M Cost
1.	Van, Gasoline	$30,900	4	Not Available	Not Available	Not Available
2.	Single Wheel Van Cutaway, Gasoline	$37,080	4	Not Available	Not Available	Not Available
3G.	Dual Wheel Van Cutaway, Gasoline	$43,260	5	$24,454	10.5%	$10,139
3D.	Dual Wheel Van Cutaway, Diesel	$49,440	5	$22,126	0.0%	$6,559
4.	Purpose Built, Front Engine, Small Bus, Diesel	$79,825	6	$33,853	53.0%	$10,889
5.	Purpose Built, Rear Engine, Small Bus, Diesel	$123,600	7	$42,728	93.1%	$11,141
6.	Low Floor, Medium Duty, Front Engine Bus, Diesel	$133,900	7	$47,371	114.1%	$12,467
7.	Low Floor, Heavy Duty, Front Engine Bus, Diesel	$206,000	12	$58,711	165.4%	$15,236
8.	Heavy Duty 30' Bus, Diesel	$283,250	12	$85,501	286.4%	$24,789

Note: A response of "Not Available" means that the vehicle class does not meet your requirements for minimum turning radius, maximum passenger capacity, or combinations thereof.

***STVe* Report** is based only on economic factors. Vehicle selection must also consider non-financial factors. Please refer to the User's Guide.

ID: MOUNTS

Today's Date: 8/16/99

Scenario B: Figure B-2.

APPENDIX B

DETAILS ON THE ECONOMIC MODEL

STV*e** (S***mall ***T***ransit ***V***ehicle **e**conomics) is an economic model designed for transit planners and others making decisions about the purchase of small transit vehicles. The model assists in the evaluation of different types of smaller vehicles prior to acquisition.

Overall Modeling Approach

The most critical issue in planning transit services (in addition to ridership) is how much it will cost to equip and operate particular services. The development of reliable cost estimates is an important element, both in making capital decisions and in planning services, since these estimates are used to determine the cost effectiveness and the financial feasibility of operating various types of services and vehicles.

Some of the planning questions relate to the *economics* of the decision: does it make sense to invest in the particular vehicle? Other issues are *nonfinancial,* but must be considered in the decision-making process. Both are addressed in the User's Guide, but only the economics of the decision are considered in the computer model.

Finding the appropriate vehicle type for a given service in a specific operating environment begins by viewing the quantitative part of the decision process as an investment decision. The research team took the approach to the development of an economic decision-making model that is based on classic engineering economy principles[1] more recently referred to as life cycle costing. Unlike an accounting problem, the engineering economy approach is concerned with differences rather than apportionment of costs. It is important to understand that under this approach all actions of the past are irrelevant and that the differences between alternatives are now or in the future. This implies that this study is based on forecasts, which uses the present situation as a base condition, and that conclusions from the analysis are dependent on the prediction or estimates of future events. Therefore, the many factors that are associated with this procedure are retained as variables, which may be changed or modified to suit differing forecasting perspectives. This model approach allows the user to test results by changing input variables.

Buying public transit vehicles can be considered a business decision, with the objective of making the best possible use of limited resources. This decision involves determining from an array of available vans and smaller buses, which type of vehicle to purchase and operate that best suits the expected travel needs of a particular community. The model ***STV*e** is based on the principles of engineering economy and therefore provides information concerning the projected economic differences of various types of vehicles operating under like conditions during the same time period. The results obtained from the model are probably not precise, because they are based on assump-

[1] For example, Grant, E. L. and Ireson, W. G., *Principles of Engineering Economy*, The Ronald Press Company, New York, NY, 4th edition (1960).

tions and estimates, which are subject to error. Nevertheless, in using the model, the chances of getting the right answer are significantly greater than what an operator may have been doing in the past.

Thus, ***STV*e** is based on the principles of engineering economy and provides information concerning the projected economic differences of various types of vehicles, operating under like conditions during the same time period. This allows the user to assess whether it makes **economic** sense to invest in a particular type of vehicle.

Most investment problems, and this would include the acquisition and operation of public transit vehicles, involve determining what makes sense in the long run, which is *years*, not days. For such problems, it is necessary to recognize the *time value of money*. This concept—the time value of money—exists because of *interest*. Because of the existence of interest, a dollar today is worth more than the promise of a dollar next year or sometime later in the future. This is why banks pay you interest when you deposit your money into their accounts. To calculate the fact that money today is worth more than the prospect of that same amount of money in the future, economists use a *discount rate* (also referred to as an interest rate). This allows the economic analysis to *discount* future money back to present time, essentially calculating future money's present worth.

In the development of ***STV*e**, the researchers determined the most appropriate *discount rate* to use for the model's calculations. The best documented sources on economic analyses and discount rates say there is no single right number because of the many factors affecting its choice,[2] in addition to the imperfection and unpredictability of the economy. "The rate must be chosen as a matter of judgment."[3] The U.S. Congress has weighed in on discounting analysis and rates of return: a Congressional Committee on the topic stated that "depending on the system of weights adopted, this rate is currently in the 8–10 percent range."[4]

Building on the Congressional Committee findings, the default discount rate set for ***STV*e** is 8.5 percent. However, the discount rate can be defined by the user, and it is strongly suggested that users conduct each evaluation of vehicle alternatives using three or more discount rates, for example, 5 percent, 10 percent, and 15 percent. By using several different discount rates for the model's analysis, the effect of the discount rate will be shown.

When users review the results of a model calculation, if the same vehicle class always has the lowest equivalent annual cost using an appropriate range of discount rates, it is safe to assume that any reasonable discount rate will have little or no effect on your economic decision. If, on the other hand, using the range of interest rates results in more than one vehicle class having the lowest equivalent annual cost, then noneconomic factors should weigh heavily in the selection decision.

Several things must be recognized about this model:

- As an economic model, ***STV*e** does not consider noneconomic factors. These may be as important or more important in the decision-making process as economic (monetary) factors. Quality of ride, enhancement of air cleanliness, low noise levels, and vehicle aesthetics are examples of noneconomic factors. Part 8 of the

[2] For example, see "Factors Considered in Setting *I**," Eugene Grant, W. Grant Ireson, and Richard S. Leavenworth, *Principles of Engineering Economy*, 8th ed., John Wiley & Sons, New York (1990), p. 325.

[3] Robley Winfrey and Carl Zellner, "Summary and Evaluation of Economic Consequences of Highway Improvements," *NCHRP Report 122*, Highway Research Board, National Research Council, Washington, DC (1971) p. 35.

[4] U.S. Congress, Joint Economic Committee, Subcommittee on Economy in the Government. Report on the Economic Analysis of Public Investment Decisions: Interest Rate Policy and Discounting Analysis, Government Printing Office, Washington, DC (1968), p. 16. This report is the last known published Congressional Committee report on the topic.

User's Guide discusses an array of noneconomic factors that should be considered. Depending on your agency's situation or your community's goals and objectives for transit, one or more of the noneconomic factors may be the critical determinant in the selection of the type of vehicle for your community.

- The model is designed to compare the future cost differences of different classes of small transit vehicles from the perspective of the owners of the transit agency, i.e., local government(s). This is not to imply that the broader perspectives of state and federal governments cannot be accommodated in using the model, but, rather, that the economic results may differ from those for local government(s).
- The model, in its present form, incorporates most of the key factors that contribute to the cost of owning and operating small transit vehicles, including capital purchase, fuel and tires, and mechanical maintenance labor and parts. The research project that developed the model considered the subjects of vehicle leasing, extending vehicle life through major maintenance overhaul, and maintenance servicing including vehicle cleaning and fueling. However, a lack of suitable quantitative information prevented further consideration of those factors.
- The model does not consider the ancillary costs of vehicle operators, nor questions of whether the selection of larger vehicles will thus require fewer vehicles to accommodate total passenger requirements. Fewer large vehicles would result in lower total vehicle operator labor costs but, of course, decrease service headways. The model assumes that the same number of transit vehicles will be required regardless of the vehicle size.

Because the model uses capital, operating, and maintenance data and costs, the model must be able to equate present and future costs, both continuously and at single points in time as might be incurred by two or more alternatives. Three standard procedures used to combine present and future expenditures are annual cost, present worth, and rate of return methods.

The model uses the **net present value** or **present worth** method of computation. Comparative costs are calculated in the model based on the concept of net present value or present worth over a defined period (the net present value provides a measure of the current value of the sum of a stream of cash outlays for transit vehicle capital, operating, and maintenance purposes reflecting the fact that despite inflationary costs, the dollars spent in the future are not as valuable to us as the dollars spent today).

What the Model Does Internally

The model's computational logic may be summarized as deductive reasoning. Once variable input values have been entered or default values accepted by users, the model computes tables of yearly capital, operating, and maintenance costs for each candidate vehicle class. "Current cost" values for each class are computed for each year of the economic analysis period based on computations of the input variable values and tables of unit cost, labor hours, and fuel consumption rates associated with each vehicle class contained in Table 1.

After the yearly current-year cost tables for each vehicle class have been computed, present worth cost tables are internally calculated by multiplying current cost values in the yearly tables by single-year present worth factors to result in present worth cost tables.

Present Worth Cost[5] = Current Cost $(1/((1 + I)^{\wedge}(n)))$

where

I = interest rate; and
n = year within the analysis period

Columns of the present worth cost tables are then summed and combined to represent the total present worth cost for each vehicle class during the analysis period. Present worth costs are converted to capital, operating, maintenance, and total equivalent annual costs to help users better understand the results of the economic analysis. This conversion to equivalent annual costs can easily be accomplished as follows:

Equivalent Annual Costs[6] = Present Worth Cost $((I*(1 + I)^{\wedge}(n))/(((1 + I)^{\wedge}(n)) - 1))$

where

I = interest rate; and
n = total number of years in the analysis period

Along with equivalent annual costs for alternative vehicle classes, percentage differences between capital, operating, maintenance, and total economic costs are reported together on a single page for users. If users are not sure about the value of input variables, they may modify their input values and run the model to determine the changes in equivalent annual costs. Thus, the total economic costs are equal to the net present value times the sum of the capital, operating, and maintenance costs.

Capital Cost Estimates

In the model, capital costs include the funds required to purchase transit vehicles. The model does not include the possibility of leasing transit vehicles or conducting major overhauls to increase vehicle life expectancy. Capital costs also do not account for salvage value.

Capital costs for transit equipment are based on the number, size, and type of equipment. Vehicle costs are based on the price of the vehicle and its life expectancy. This allows the model to consider the concept of "life cycle costing" and account for the fact that different vehicles have very different life expectancies.

The funding source (and required local share for capital) can also interact with the vehicle life span and the time value of money to shift decisionmaking on vehicles in favor of one type or another. The model takes into account the portion of the capital cost that has to be contributed by the local system. If few local dollars are involved, it may seem to make sense to a local system to purchase the vehicles with the longest projected life, even if they are the most expensive to purchase and they provide excess capacity—as long as the higher operating costs do not offset the capital cost savings. On the other hand, a system with more local dollars involved may well be more sensitive to the time value of money and choose cheaper vehicles with a shorter life span. Recent changes in

[5] **Present Worth Costs** provide a measure of the sum of a stream of cash outlays for transit vehicle capital, operating, and maintenance purposes reflecting the fact that despite inflationary costs, the dollars spent in the future are not as valuable to us as the dollars spent today.

[6] **Equivalent Annual Costs** represent the amount of money that would have to be spent each year to fund the capital, operating, and maintenance requirements of transit vehicles into the future. This is an analytical abstraction and does not reflect actual cash outlays.

federal transit funding programs to reduce or eliminate operating assistance, while maintaining funding for capital may increase the incentives for systems to buy vehicles with a long life—unless the differences in maintenance and fuel costs (which are increasingly local) are greater than the savings in the local share of capital costs.

Operating and Maintenance Cost Estimates

In the model, operating costs include the fuel consumption and tire replacement costs of transit vehicles. Maintenance costs include maintenance labor costs and maintenance parts costs during the economic analysis period. Operating costs do not include the cost of daily fueling, cleaning, and servicing of transit vehicles.

Service characteristics define the resources needed, and the prices are used to estimate a cost for each of these resources. There are two general approaches that can be considered in estimating operating and maintenance costs: (1) cost allocation models and (2) resource build-up models. The model uses the second approach, a **"resource build-up" model**, also often called "causal factor" model, to estimate operating and maintenance costs for the various vehicles. In this approach, costs are estimated using the quantities of components needed to provide a particular level of service (e.g., mechanic hours, gallons of fuel, tires) and then multiplying these quantities times the unit costs for the labor or materials for different vehicle types.

Vehicle and Cost Data Tables

The model includes a number of vehicle and cost tables that include the data used by the program to calculate the equivalent annual cost and operating and maintenance costs. Some of these tables include data collected directly from the manufacturers or the literature (e.g., useful life, capital costs, interest rates) and some were constructed based on data collected during Phase II of the project.

Vehicle Characteristics Table. The vehicle characteristics table includes information on the vehicles, their capital and overhaul costs, life expectancy, fuel consumption rates, turning radius, passenger capacity, and so on. The vehicle life is defined in years, but no provision is being made for salvage values. Since planners using the model may have some information on the service or operating environment (e.g., needed vehicle capacity or minimum maneuvering space), the model allows users to specify a minimum turning radius or vehicle capacity. Vehicles not meeting the minimum turning radius or passenger capacity are not considered in the analysis.

Service Variables. Service variables are factors which describe how vehicles will be used or the conditions under which vehicles are expected to operate. These variables are expected to reasonably define the types of services performed by small vehicles. Service variables in the model include where the service will be provided (by state), the year service would begin, annual vehicle miles, and the type of service. Differences in service operating characteristics are reflected in the model using different speeds for different service types.

In the model, a number of look-up tables include data defining the relationship between service variables and operating and maintenance cost. Each vehicle class has associated tables of annual maintenance labor hours per vehicle mile, annual parts cost per vehicle mile, base fuel consumption rates, and tire costs per mile for look-up purposes. The *service type* affects the operating speed and thus the efficiency of fuel consumption. Very slow or very fast rates of vehicle operating speeds generally result in higher rates of fuel consumption per vehicle mile. One of the tables uses service characteristics to define the operating speeds for each service type. The *service level* (miles and days of service) affects tires, fuel, and vehicle maintenance cost. The *service location* indicates climate and indicates differences in operating costs due to weather conditions such as warm and cold climates. It is assumed that hot and/or cold climate conditions could have an adverse effect on the time and costs associated with maintenance labor and parts. One of the tables is designed to use the states to define differences in maintenance costs due to climate and weather.

Cost Variables

Capital Cost. A menu of default capital costs is provided for each candidate vehicle classification that includes a supply of spare parts, warranty coverage, training, and other deliverables contained in normal bid specifications. Users have the option to override any or all capital costs. **Vehicle Life Expectancy** is considered a variable in the model because different transit vehicles have different useful lives. The estimated life expectancy of each vehicle classification is part of the vehicle classification table (Table 1).

Operating and Maintenance Costs

Mechanical Labor and Parts are model variables because different transit vehicle types exhibit a history of dissimilar costs. Regardless of the type of vehicle, maintenance costs seem to follow a similar pattern of escalation over the life of the vehicle. During the life of transit vehicles, maintenance costs tend to pass through four phases of exposure to wear and failure. Since small transit vehicles have a shorter useful life expectancy and heavy-duty transit vehicles have a longer life, these phases occur at different times during the life cycle. Tables in the model reflect the number of mechanic labor hours and part costs per vehicle mile necessary to provide mechanical maintenance services for each vehicle classification.

Tire Cost is considered a variable because tire wear experience can differ for each vehicle type and average annual service mileage varies among agencies. As is often experienced, the characteristics of different types of vehicles require different types of tires. Some larger vehicles can use a conventional bias-ply transit lease tire, whereas, smaller vehicles may require the use of radial tires. In the frequent exposure to the curbs, radial tires on smaller vehicles are subject to irreparable damage to the sidewalls resulting in extra charges for damaged casings by the tire supplier. Model tables provided tire cost per vehicle mile for each vehicle classification. Tire costs were constructed by contacting national tire manufacturers and collecting tire cost and wear rates.

Fuel Consumption Rate is a variable because different vehicles consume fuel at different rates based on factors such as vehicle size and engine/transmission design, operating speeds, passenger loads, fuel types, and operating environment. The model includes a table for each vehicle classification that indicate base consumption rates per vehicle mile. Alternative fuels are not considered in the model which uses standard fuel types for different vehicle classes.

Labor Variables are factors that define labor cost characteristics of transit systems which may vary by location or may vary within an organization. Employees are often paid at rates that vary by the work performed. Mechanic and servicing labor rates that are compatible with agency or local wage rates will be specified by users for use in determining mechanical maintenance wage costs for each vehicle type. In the software screens, a default average vehicle mechanic rate is provided based on national estimates and is included in a default table. Users have the option to override the labor rate to reflect agency or local experience. Fringe benefit rates that are compatible with agency or local fringe benefit rates for mechanics will be specified by users for use with labor rates in determining vehicle mechanical maintenance and servicing labor costs for each vehicle type. In the software screens, default average fringe benefit rates will be provided based on national estimates of mechanics. Users have the option to override the rates to reflect agency or local experience.

Fuel Unit Cost Rates can have significant consequences on present and future operating costs and thus on the investment decision of transit vehicles. Future energy shortages could increase the future cost of fuel significantly higher than the rate now being experienced and thus must be considered in any analyses of future cost. In the software screens, default average fuel costs are provided based on national estimates of different fuel types.[7] Users have the option to override the rates to reflect agency or local experience. These unit cost rates are used with fuel consumption rates to develop a yearly fuel cost table for each candidate vehicle classification.

Time Value of Money or Interest Rate recognizes that a dollar today is worth more than the prospect of a dollar next year or at some other later time. Using an interest rate also recognizes that estimates far into the future will be less precise than those for today and the near future. In this model, the value of future monetary expenditure (in current dollars) would be discounted using the present worth method of analysis. The assumed interest rate in the present worth calculations is treated as a variable.

Impact of Funding Source on Decisionmaking. The percentage of the capital cost that is contributed by the local entity is included as a model variable since the level of local involvement in capital acquisitions can affect the economic decision-making process. Economists have often pointed out that the higher federal match for transit capital may well cause local recipients to "over-capitalize," choosing projects with higher capital costs and lower operating costs than they would if funding were provided without restrictions on its use. While this critique is usually raised in discussions of capital-intensive rail projects, it may also have some bearing on a system's vehicle size decision as well. The wide variance in vehicle life span can interact with the time value of money, and the funding source to shift decisionmaking on vehicles in favor of one type or another. As mentioned above, if few local dollars are involved, it may seem to make sense to a local system to purchase the vehicles with the longest projected life even if they are the most expensive to purchase and they provide excess capacity—as long as the higher operating costs do not offset the capital cost savings. On the other hand, a system with more local dollars involved may be more sensitive to the time value of money, and, therefore, may choose cheaper vehicles with a shorter life span.

[7] The model does not include a default fuel type, but rather gives users the opportunity to choose a fuel where alternative fuel options exist. As the model is currently structured, the user can compare the same vehicle using different fuel types only by running the model multiple times, one for each type of fuel being considered.

The **Transportation Research Board** is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results. The Board's varied activities annually draw on approximately 4,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation

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