Victoria Transport Policy Institute
1250 Rudlin Street, Victoria, BC, V8V 3R7, CANADA
www.vtpi.org info@vtpi.org
Phone & Fax 250-360-1560
"Efficiency - Equity - Clarity"

Evaluating Public Transit Benefits and Costs

Best Practices Guidebook

by
Todd Litman
Victoria Transport Policy Institute
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Abstract

This guidebook describes how to create a comprehensive framework for evaluating the full impacts (benefits and costs) of a particular transit service or improvement. It identifies various categories of impacts and how to measure them. It discusses best practices for transit evaluation and identifies common errors that distort results. It discusses the travel impacts of various types of transit system changes and incentives. It describes ways to optimize transit benefits by increasing system efficiency, increasing ridership and creating more transit oriented land use patterns. It compares automobile and transit costs, and the advantages and disadvantages of bus and rail transit. It includes examples of transit evaluation, and provides extensive references. Many of the techniques in this guide can be used to evaluate other modes, such as ridesharing, cycling and walking.

Contents

Introduction 2
Evaluation Best Practices 6
Evaluating Transit Service Quality 8
Travel Impacts 10
- Indirect Travel Impacts 12

Transit Demand 13
Transit Impact Categories 18
- Transit Expenditures 18
- Impacts on Existing Transit Users 19
- Mobility Benefits 20
  - User Benefits 20
  - Public Service Support 20
  - Equity Benefits 21
  - Option Value 21
- Efficiency Benefits 24
  - Vehicle Cost Savings 25
  - Avoided Chauffeuring 26
  - Congestion Reduction 27
  - Parking Cost Savings 36
  - Safety, Health and Security Impacts 38
  - Roadway Costs 42
  - Energy Conservation and Emission Reductions 44
- Travel Time Impacts 47
- Land Use Impacts 50
- Economic Development Impacts 53
- Impact Summary 57

Evaluating and Quantifying Transit Benefits 58
Comparing Transit and Automobile Costs 61
- Perspectives 64
- Common Errors Made When Comparing Transit and Automobile Transport 67

Evaluating Transit Criticism 68
Rail Versus Bus Transit 71
Strategies To Increase Transit Benefits 75
Evaluation Examples 77
Conclusions 88
References And Resources For More Information 89

Introduction

Public Transit includes various services that provide mobility to the general public in shared vehicles, ranging from shared taxis and shuttle vans, to buses and passenger rail systems. This guidebook describes how to evaluate the value to society of a particular transit service or change in service. It explains how to create a comprehensive evaluation framework that incorporates various categories of impacts (benefits and costs), and how to quantify these impacts. It discusses how to determine whether a particular public transit program is worthwhile, and how to optimize transit services to maximize benefits. This analysis framework can also be used to evaluate other modes such as ridesharing.

There are many reasons to improve transit evaluation practices. Current transportation evaluation practices are not very effective at evaluating multiple modes. They tend to overlook some categories of transit benefits and so undervalue transit. More comprehensive evaluation provides more accurate information for transportation planning.

This is not to suggest that every transit project is cost effective or that transit is always the best solution to every transport problems (Dittmar, 1997). However, it indicates the importance of using comprehensive analysis that takes into account various factors that are often overlooked when evaluating transit and planning a truly optimal transportation system.

A challenge in developing this document is to maintain a balance between keeping it simple enough to be convenient to use while providing sufficient detail to address all possible situations. To achieve this, the document describes concepts and issues, and provides recommended evaluation techniques and default values, and offers numerous reference documents for additional technical detail.

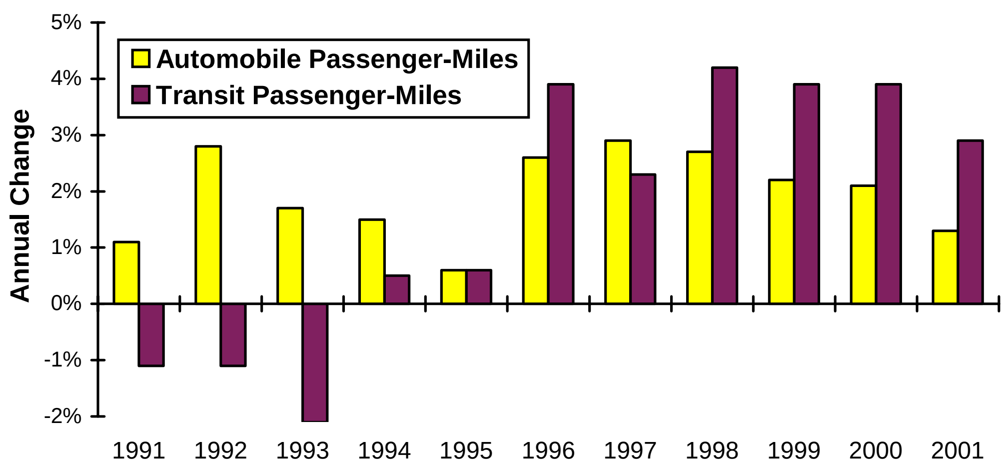
Transit's Role In A Modern Transportation System

Looking back over the last century, public transit may seem to be of declining importance. Critics argue that outside a few major cities there is little justification to expand transit service or encourage transit use (Cox, 2000; Orski, 2000; Balaker, 2004). For many decades automobile use (here "automobile" includes cars, light trucks, vans and SUVs and motorcycles) grew, matched by a downward spiral in transit ridership, investment, and service quality. Land use patterns became more automobile oriented, and urban populations declined. But there are also counterbalancing factors which suggest that transit may become more important in the future:

- There is growing appreciation of potential benefits from integrating transport and land use planning to create more accessible, multi-modal communities.
- Many cities have recently experienced redevelopment and population growth, and some trends (smaller households, more elderly people, increased popularity of urban loft apartments, increased value placed on walkability, etc.) support increased urbanization.
- Many cities have reached a size and level of traffic demand that justifies more reliance on transit, including many areas previously classified as *suburban* that are becoming more urbanized, and so experience increased congestion, commercial clustering, land values and parking problems that make transit cost effective.
- There is a growing realization among transportation professionals and much of the general public that there is a value to having a more diverse transportation system.
- Various combinations of aging populations, traffic problems and environmental concerns are motivating many people to value transit services.

Transit and cities are now experiencing a renaissance. Since the mid-1990s transit ridership has increased, and many cities have experienced redevelopment and growth, as indicated in Figure 1.

Figure 1 **Highway and Transit Travel Trends** (BTS, 2003, Table 1-34)



Between 1998 and 2001 transit travel grew faster than automobile travel.

Most communities now have well-developed automobile transport systems. Increasing automobile dependence creates a variety of problems, many of which public transit can help solve. Transit tends to be most effective in dense urban areas where automobile problems are greatest. As a result, when all impacts are considered, transit is often the most cost-effective way to improve transportation.

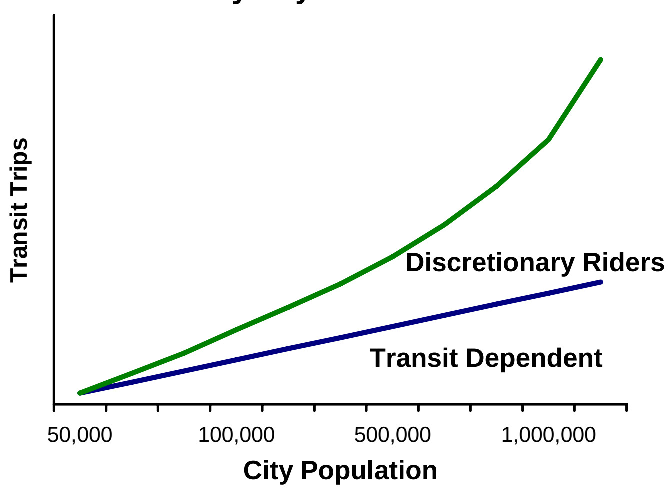
Table 1 **Transportation Problems Transit Helps Solve**

• Traffic congestion	• Automobile costs to consumers.
• Parking congestion	• Inadequate mobility for non-drivers
• Traffic accidents	• Excessive energy consumption
• Road and parking infrastructure costs.	• Pollution emissions

Public transit can help address a variety of transportation problems. Transit tends to be most effective on dense urban corridors where these problems are most intense.

Transit becomes more important as cities grow. In smaller cities transit primarily serves *transportation disadvantaged* riders (people cannot use an automobile), typically representing 5-10% of the population, but as cities grow in size and density transit serves more *discretionary riders* (people who have the option of driving), and so provides more benefits by reducing traffic problems and supporting more efficient land use patterns.

Figure 2 **Transit Use By City Size**



As a city increases in size, transit ridership increases as more discretionary riders (people who have the option of traveling by automobile) use transit.

This does not mean that every automobile trip should shift to transit or that transit can solve every urban problem. But there are frequently-overlooked benefits from having a diverse transport system ("Evaluating Transportation System Diversity," VTPI, 2004). Although few motorists want to give up automobile use completely, at the margin (i.e., compared with their current travel patterns) many would prefer to drive somewhat less and use alternatives more, provided they are convenient, comfortable and affordable.

The Importance of Comprehensive Analysis

Economists and planners have developed computer models and various analysis tools for evaluating the economic value of specific transport options. These were generally developed to evaluate a particular mode or objective. For example, highway investment models are designed to measure the value of road improvements, and emission reduction models are designed to prioritize emission reduction strategies. Because of their limited scope, these tools tend to be ineffective at evaluating multiple modes and planning objectives ("Comprehensive Evaluation," VTPI, 2004).

For example, models designed to evaluate congestion reduction strategies often ignore emission impacts, and models designed to evaluate emission reductions often ignore congestion impacts. Many models ignore parking and vehicle ownership costs. Such "reductionist" models can favor solutions to one problem that exacerbate others, and undervalue strategies that provide modest but multiple benefits, such as transit services.

Conventional transport evaluation models tend to undervalue public transit because they overlook many benefits, as summarized in Table 2. To their credit, many public officials realize that transit provides more benefits than their models indicate, and so support transit more than is justified by benefit/cost analysis, but this occurs despite rather than as a result of formal economic evaluation. Decision making would improve with better evaluation models that account for more impacts.

Table 2 **Impacts Considered and Overlooked** ("Comprehensive Evaluation" VTPI, 2004)

Usually Considered	Often Overlooked
Financial costs to governments Vehicle operating costs (fuel, tolls, tire wear) Travel time (reduced congestion) Per-mile crash risk Project construction environmental impacts	Downstream congestion impacts Impacts on non-motorized travel Parking costs Vehicle ownership and mileage-based depreciation costs. Project construction traffic delays Generated traffic impacts Indirect environmental impacts Strategic land use impacts Transportation diversity value (e.g., mobility for non-drivers) Equity impacts Per-capita crash risk Impacts on physical activity and public health Some travelers' preference for transit (lower travel time costs)

Conventional transportation planning tends to focus on a limited set of impacts. Some tend to be overlooked because they are relatively difficult to quantify (equity, indirect environmental impacts, crash risk), and others are ignored simply out of tradition (parking costs, long-term vehicle costs, construction delays). These omissions tend to undervalue transit improvements.

Recent research expands the range of impacts to consider in transit evaluation (Cambridge Systematics, 1998; Cambridge Systematics, 1999; Lewis and Williams, 1999; TRB, 2000; Phillips, Karachepone and Landis, 2001; HLB, 2002; ECONorthwest and PBQD, 2002; MKI, 2003; Nelson, et al, 2006). This guide summarizes this research and describes how to apply more comprehensive evaluation in a particular situation.

Evaluation Best Practices

Economic Evaluation (also called *Appraisal* or *Analysis*) refers to methods to determine the value of a planning option to support decision making (Litman, 2001). Economic evaluation involves quantifying and comparing the marginal (incremental) impacts (benefits and costs) of various options in a standardized format.

Economic evaluation requires an *evaluation framework* that specifies the basic structure of the analysis. This identifies the following ("TDM Evaluation," VTPI, 2004):

- *Evaluation method*, such as cost-effectiveness, benefit-cost, lifecycle cost analysis, etc.
- *Evaluation criteria*, which are the impacts to be considered in the analysis. Impacts can be defined in terms of *objectives* or their opposite, *problems* (for example, congestion reduction is an objective because congestion is considered a problem), or they can be defined in terms of *costs* and *benefits* (for example, congestion reduction benefits can be measured based on reduced congestion costs).
- *Modeling techniques*, which predict how a policy change or program will affect travel behavior and land use patterns.
- *Base Case*, meaning what would happen without the policy or program.
- *Comparison units*, such as net present value, benefit/cost ratio, or cost per lane-mile, vehicle-mile, passenger-mile, incremental peak-period trip, etc.
- *Base year and discount rate*, which indicates how costs are adjusted to reflect the time value of money.
- *Perspective and scope*, such as the geographic range of impacts to consider.
- *Dealing with uncertainty*, such as use of sensitivity analysis or other statistical tests.
- *How results are presented*, so that the results of different evaluations can be compared.

It is important to carefully define the questions and options to be considered. A transit evaluation may consider whether a particular transit investment is cost effective (benefits exceed costs), which of several transit options provides the greatest net benefits, whether a transit improvement provides more value than a highway improvement, and how to optimize transit service benefits, and how the benefits and costs of a transportation option are distributed. It is generally best to evaluate several options, which may include a base case (what happens if no change is implemented), and various roadway improvements, transit improvements, and support strategies. Transit options might include small, medium and large service improvements, plus transit improvements combined with various support strategies such as ridership incentives and transit-oriented development. All quantified values and calculations should be incorporated into a clearly-organized spreadsheet, which allows various options and assumptions to be tested and adjusted.

Some benefits and costs have a mirror-image relationship; a cost increase can be considered a reduction in benefits, and a reduction in benefits can be considered an increase in costs. For example, reduced accidents can be defined as increased road safety, and reduced congestion delays can be described as an increase in mobility.

Transit system costs tend to be relatively easy to determine, since most show up in government agency budgets. The main challenge is therefore to identify all incremental benefits. Some impacts are difficult to monetized (measured in monetary units) with available analysis tools and data. Such impacts should be quantified as much as possible and described. For example, it may be impractical to place a dollar value on transit equity benefits, but it may be possible to predict the number and type of additional trips made by transportation disadvantaged people, and to discuss the implications of this additional mobility on their ability to access basic services, education and employment.

Analysis should reflect *net*, *marginal* impacts. For example, net pollution reductions are the reduced automobile emissions minus any additional transit vehicle emissions. Marginal (incremental) impacts are sometimes difficult to determine. A 10% increase in transit passenger-miles does not necessarily increase transit costs by 10% if additional ridership occurs when the system has excess capacity.

Total impacts include both direct and indirect effects. Direct impacts result from increased mobility provided by transit, and reduced automobile use when people shift from driving to transit. Indirect impacts result when a major transit improvement provides a catalyst for more accessible land use patterns and a more diverse transportation system that results in additional reductions in automobile travel. This "leverage" effect is discussed later. Analysis that only considers direct impacts and uses a short-term perspective tends to undervalue transit, particularly rail transit.

Some impacts can be considered in multiple categories, so it is important to avoid double-counting. For example, productivity gains from more accessible land use can be counted as land use benefits or economic benefits, but not both.

Some impacts are economic transfers rather than net gains. It is important to identify their full effects. For example, from a local perspective, federal grants can be considered a net economic gain, since the money originates from elsewhere, but at a national level these are economic transfers, resources shifted from one area to another. Similarly, taxes and fares are economic transfers, costs to those who pay, and benefits to those who gain the revenue. Both types of impacts should be considered in economic evaluation.

In general, it is best to calculate all impacts, including those that are indirect, long-term and affecting other jurisdictions, and identify their distribution by category, time, geographic area, and group. For example, a transit improvement might provide $10 million dollars in total net benefits, of which $6 million is direct and $4 million is indirect, $4 million occurs within the first 5 years, $6 million accrues within the local jurisdiction, and $2 accrues to lower-income people.

Evaluating Transit Service Quality

Service quality refers to how transit is perceived by users. Kittleson & Associates (1999), Pratt (1999), Rood (1999), Phillips, Karachepone & Landis (2001), Tumlin, et al (2005), AARP (2005), and Marsden and Bonsall (2006) provide guidance on evaluating transit service quality from various perspectives, including the following factors:

- Availability (when and where transit service is available), and coverage (the portion of a geographic area, or the portion of common destinations in a community, located within reasonable distance of transit service.
- Frequency (how many trips are made each hour or day).
- Travel speed.
- Reliability (how well actual service follows published schedules)
- Integration (ease of transferring between transit and other travel modes)
- Price structure and payment options.
- User comfort and security, including riding on, walking to, and waiting for transit vehicles.
- Accessibility (ease of reaching transit stations and stops, particularly walkability), and local street design quality.
- Affordability (user costs relative to their income and other travel options).
- Information (is information on transit service easy to obtain and understand)
- Aesthetics (appearance of transit vehicles, stations, waiting areas and documents)

Transit service quality can be evaluated by having trained observers rate from A to F the reliability, cleanliness, comfort, and other features on a representative sample of bus trips (CPHA, 2002). The results are published in an annual report.

Transit service quality can be compared with other modes. For example, travel speed, comfort and affordability can be compared with those of automobile travel for the same trips. These factors should be evaluated for various types of users, trips and travel conditions. For example, transit service may be frequent and convenient during weekdays, but infrequent in the evenings and on weekends, and so service quality is inferior for users who want to make trips at those times. If only some buses have wheelchair lifts, transit service can be unreliable and inconvenient for some people with disabilities. A section later in this report discuss how to evaluate the value of transit travel time and compare it with other modes, taking into account differences in user comfort.

Travel time maps use *isochrones* (lines of constant time) to indicate the time needed to travel from a particular origin to other areas (Lightfoot and Steinberg, 2006). For example, areas within one hour may be colored a dark red, within two hours a lighter red, within three hours a dark orange, and within four hours a light orange. Maps can indicate and compare travel times by different modes. For example, one set of maps could show travel times for automobile travel and another for public transit travel. Travel time maps are an indication of accessibility.

Table 3 compares the factors considered in various transit service quality indices. Newer indices tend to be more comprehensive, and therefore more accurate at evaluating service quality and predicting the effects of changes in transit service and accessibility.

Table 3 **Transit Indices Compared** (Fu, Saccomanno and Xin, 2005)

Indices	Studies	Performance Factors Incorporated	Reflects Transit Availability?	Reflects Comfort and Convenience?	Reflects Travel Demand?
Local Index of Transit Availability	Rood, 1997	Frequency; capacity; route coverage	Yes	No	No
Public Transportation Accessibility Level	Hillman,	Service frequency; service coverage	Yes	No	No
Transit Level of Service Indicator	Kittelson & Associates and URS, 2001	Service coverage; frequency; service span; population; jobs	Yes	No	Yes
Transit Service Accessibility Index	Polzin et al., 2002	Service coverage; service span; frequency; travel demand	Yes	No	Total number of trips
Mobility Index	Galindez and Mireles-Cordov, 1999	Travel speed; average vehicle occupancy	No	Yes	No
Service Quality Index	Hensher et al., 2001	13 variables (i.e., travel time; frequency, etc.)	Yes	No	Yes
Transit Service Indicator (TSI)	Fu, Saccomanno and Xin, 2005	Service frequency, coverage, and various travel time components (walk, wait, transfer, and ride)	Yes	Yes	Yes

This table compares various indices that can be used to evaluate service quality and predict the effects of service changes.

Travel Impacts

The benefits of a transit service or improvement are affected by the type of travel impacts it causes. The table below indicates the effects of various types of transit improvements. For example, some improvements provide basic mobility or increase affordability. Some are particularly effective at attracting motorists and reducing automobile travel.

Table 4 **Travel Impacts of Various Transit Improvements** (VTPI, 2004)

Type of Transit Improvement	Improved Service Quality	Increased Affordability	Provides Basic Mobility	Reduces Auto Travel
Additional routes, expanded coverage, increased service frequency and hours of operation.	X		X	X
Lower fares, increased public subsidies.		X	X	X
More special mobility services.		X	X	
Commute Trip Reduction programs, Commuter Financial Incentives, and other TDM Programs that encourage use of alternative modes.		X		X
HOV Priority.	X			X
Comfort improvements, such as better seats and bus shelters.	X			X
Transit Oriented Development and Smart Growth, that result in land use patterns more suitable for transit transportation.	X			X
Pedestrian and Cycling Improvements that improve access around transit stops.	X		X	X
Improved rider information and Marketing programs.	X			X
Improved Security.	X		X	X
Targeted services, such as express commuter buses, and services to Special Events.	X			X
Universal Design.	X		X	
Park & Ride facilities.	X			X
Bike and Transit Integration (bike racks on buses, bike routes and Bicycle Parking at transit stops).	X		X	X

This table summarizes the travel impacts of various transit improvements. Some improve conditions or reduce costs for existing riders, others cause shifts from automobile to transit.

User benefits result from improved convenience, speed, comfort or financial savings to current transit users, that is, for trips that would be made by transit even without those improvements. For example, if transit priority measures increase transit speeds, current users benefit from travel time savings. Similarly, bus shelters, improved security at transit stations, reduced fares, and other types of service improvements provide benefits to current transit users.

Mobility benefits result from the additional mobility provided by a transportation service, particularly to people who are physically, economically or socially disadvantaged. These benefits are affected by the types of additional trips served. For example, transit services that provide *basic mobility*, such as access to medical services, essential shopping, education or employment opportunities, can be considered to provide greater benefits than more luxury trips, such as recreational travel ("Basic Mobility," VTPI, 2004).

Efficiency benefits result when transit reduces the costs of traffic congestion, road and parking facilities, accidents and pollution emissions. These benefits depend on the amount and type of automobile traffic reduced. For example, transit services provide extra benefits if they reduce urban-peak automobile trips, rather than off-peak or rural trips, because urban-peak automobile travel tends to impose the greatest congestion, parking and pollution costs. Table 5 compares mobility and efficiency objectives.

Table 5 **Comparing Mobility and Efficiency Objectives**

	Mobility	**Efficiency**
Objective	Increase mobility by non-drivers.	Reduce costs such as congestion and pollution.
How it is evaluated.	Quality of mobility options available, particularly for disadvantaged people.	Compared with the same trips made by automobile.
Service distribution and coverage.	Structured to provide the greatest possible coverage, including service at times and places where demand is low.	Focused on urban-peak travel conditions where congestion, facility costs and pollution are worst.
Service quality.	Service may be basic (i.e., bus rather than rail), but it must be comprehensive and affordable.	Designed to attract discretionary riders with premium quality service (e.g., rail rather than bus), Park & Ride, and express services.
Fare structure.	Affordable to disadvantaged people.	Attractive to commuters.

Public transit has have various objectives that sometimes conflict.

These benefits tend to be greatest when transit serve people who face the greatest mobility constraints, such as wheelchair users and people with very low incomes (Litman and Rickert, 2005). Special effort may be made to identify these users in ridership surveys and passenger profiles, evaluation of vehicle design features such as the portion of vehicles and terminals that accommodate people with disabilities (including the quality of pedestrian access in the area), and user surveys that include special features to determine the problems that disadvantaged people face using transit services.

To help analyze travel impacts it is useful to determine *mode substitution* factors, that is, the change in automobile trips resulting from a change in transit trips, and vice versa. For example, when reduced fares increase bus ridership, typically 10-50% substitute for an automobile trip. Other trips shift from nonmotorized modes, vehicle passengers (which may involve a *rideshare* trip, in which case automobile travel is not reduced when a passenger shift to transit, or a *chauffeured* trip, in which a driver makes a special trip to carry a passenger), or be induced travel. Conversely, when a disincentive such as parking fees or road tolls cause automobile trips to decline, generally 20-60% shift to transit, depending on conditions. Pratt (1999), Kuzmyak, Weinberger and Levinson (2003), and TRL (2004) provide information on the mode shifts that typically result from incentives such as transit service improvements and parking pricing.

According to the Transit Performance Monitoring System (FTA, 2002), more than half of transit passengers report that if transit service were unavailable they would travel by automobile, either as a driver or passenger in a private automobile or taxi (a portion of passenger trips would be *ridesharing*, using an otherwise empty seat without increasing vehicle mileage, while others would be *chauffeured trips* that do increase vehicle travel).

Indirect Travel Impacts

In addition to direct travel impacts, transit improvements can impact travel indirectly by providing a catalyst for more multi-modal, accessible communities where people tend to own fewer cars and drive less than would otherwise occur (Pascall, 2001; Switzer, 2003; "Land Use Impacts on Transportation," VTPI, 2004). Where high-quality transit creates more efficient land use, each transit passenger-mile represents a reduction of 3 to 6 automobile vehicle-miles (Neff, 1996; Newman and Kenworthy, 1999, p. 87; Holtzclaw, 2000; Litman, 2004a). The table below summarizes estimates of these impacts.

Table 6 **VMT Reductions Due to Transit Use** (Holtzclaw 2000; Litman, 2004a)

Study	Cities	Vehicle-Mile Reduction Per Transit Passenger-Mile	
		Older Systems	**Newer Systems**
Pushkarev-Zupan	NY, Chicago, Phil, SF, Boston, Cleveland	4	
Newman-Kenworthy	Boston, Chicago, NY, SF, DC	2.9	
Newman-Kenworthy	23 US, Canadian, Australian and European cities	3.6	
Holtzclaw, 1991	San Francisco and Walnut Creek	8	4
Holtzclaw, 1994	San Francisco and Walnut Creek	9	1.4
MTC/Raft 2010			4.4
Litman (2004)	50 largest U.S. cities.	4.4	

This table summarizes results from several studies indicating that transit, particularly rail, can leverage automobile travel reductions by changing transportation and land use patterns.

This does not mean that every transit improvement leverages automobile travel reductions of this magnitude. Basic transit service or a single transit improvement does not necessarily cause such reductions. Significant transit service improvements integrated with more accessible land use and incentives to reduce automobile use are generally needed to cause significant reductions. Rail transit tends to have the greatest impact on per-capita vehicle travel because it tends to have the greatest land use impacts. Busways probably have smaller impacts. Even rail systems can have little effect if other transportation and land use policies are not supportive, for example, if most riders drive to transit stations located in sprawled, automobile-dependent communities.

Transit Improvements Help Reduce Vehicle Ownership and Use (www.translink.bc.ca)
Despite strong population and economic growth, the city of Vancouver recorded a small decline in the number of registered automobiles, and a reduction in downtown automobile trips in 2004. Small decreases or reductions in growth rates were also recorded in nearby suburbs. Experts conclude that this results from increased transit services and a growing preference for urban living. Says expert says David Baxter, "There are some fundamental changes going on. It's increasingly possible to live in Vancouver without a motor vehicle." Transit ridership rose 9.5% in the first half of this year compared to the same period last year, and was 24.6% higher than 2002. Bus trips increased by 11.1%, and rail trips increased by 5.4%. A customer survey found that that 42% of SkyTrain riders, 49% of West Coast Express riders, 35% on the 99B bus route and 25% on the 98B route switched from commuting by car. "The numbers show that demand for public transit continues to grow in response to the significant expansion of services."

Transit Demand

Travel demand, refers to the number and types of trips people would make under particular conditions. A number of factors affect travel demand, including geography (urban area size and density), economy (number of jobs in an area) and demographics (portion of households without vehicles), as well as various transit service, design and pricing. The table below summarizes various factors affecting transit demand that can be used to increase transit ridership and the benefits provided by transit.

Table 7 **Factors Affecting Transit Ridership**

Factors	Using These Factors To Increase Ridership And Benefits
Convenience	Increase transit service coverage and frequency.
Information	Provide information on where, when and how to use transit.
Price	Keep fares low and offer targeted discounts, such as commuter passes.
Speed.	Provide express commuter services and transit priority measures.
Accessibility	Develop more accessible land use patterns and more diverse transportation systems.
Integration	Provide park & ride facilities, transit service to major transportation terminals.
Comfort	Provide adequate service so transit vehicles are not crowded.
Security	Insure that transit vehicles, facilities and service areas are considered secure.
Prestige	Treat transit riders with respect, and promote transit as a desirable travel option.

Many factors can affect ridership and benefits.

For example, a particular transit route might attract 5,000 riders per day under current conditions; 6,000 if more employers have Commute Trip Reduction programs; 7,000 if a local college has a Campus Transport Management program; 8,000 if service quality improves; 9,000 if Park & Ride, Pedestrian and Bicycle access improve; and 10,000 if Parking Management programs are implemented in the area.

For more information on transit demand see Pratt (1999); Kittleson & Associates (1999); Phillips, Karachepone and Landis (2001); IFS, 2001; Hass-Klau and Crampton (2002); FTA (2002); Taylor and Fink (2003); Litman, 2005a; TRL (2004), Fehr & Peers (2004); McCollom and Pratt (2004); Taylor, et al. (2004); and Currie (2005). The *Transit Performance Monitoring System* (TPMS) is a standardized transit user survey that provides information on who, why and how frequently people use transit (FTA, 2002).

Most urban regions have travel demand models that predict how various transport system changes affect travel patterns. However, such models are not very effective at measuring factors such as rider comfort and pedestrian accessibility, and so tend to understate transportation and land use management strategy impacts ("Modeling Improvements," VTPI (2002). Travel impacts of transit encouragement strategies can be evaluated by comparing the generalized costs (travel time and incremental expenses per trip) of transit and driving to calculate a *transit competitiveness ratio* (Casello, 2007). The higher this ratio the relatively less attractive is transit compared with driving. Because travelers have diverse needs and preferences, some will choose transit even if the transit competitive ratio is relatively high, so models must be calibrated and adjusted to reflect specific conditions.

Factors that affect transit ridership are discussed in more detail below.

Price Changes

The overall average Elasticity of transit ridership with respect to fares is -0.4, meaning that each 1.0% fare increase will reduce ridership by 0.4%, although this varies depending on various geographic, demographic and service factors (Hensher and King 1998; Pratt, 1999; TRL, 2004; Litman, 2004). Transit dependent riders have lower elasticities than discretionary riders. Large cities tend to have a lower elasticity than small cities, and peak-hour travel is less elastic than off-peak. Commuter Financial Incentives, in which employers provide subsidized passes or cash to transit riders, can be effective at increasing ridership (www.commutercheck.com). Parking Pricing can significantly increase transit travel. Even a modest fee ($1-2 per day) often doubles transit commuting. The Trip Reduction Tables indicate the reduction in automobile trips that can be expected from various combinations of commuter financial incentives.

Table 8 **Transit Ridership Factors** (JHK, 1995; Kain and Liu, 1999)

Factor	Elasticity
Regional employment	0.25
Central city population	0.61
Service (transit vehicle mileage)	0.71
Fare price	-0.32
Wait time	-0.30
Travel time	-0.60
Headways	-0.20

This table shows the elasticity of transit use with respect to various factors. For example, a 1% increase in regional employment is likely to increase transit ridership by 0.25%, while a 1% increase in fare prices will reduce ridership by 0.32%, all else being equal.

Service Quality

Pratt (1999) concludes that the elasticity of transit use with respect to transit service averages 0.5, meaning that each 1% increase in transit service frequency, vehicle mileage or operating hours increases ridership by 0.5%. There is a wide variation in this factor depending on type of service, demographic and geographic factors. Elasticities of 1.0 can occur where transit service is expanded into suitable areas. A study of U.S. travel demand found that a 10% increase in a city's bus service reduces just one average annual mile of vehicle travel per capita, but a 10% increase in rail transit service reduces 40 average annual miles of vehicle travel per capita. Pratt finds that the elasticity of transit use to service expansion (e.g. routes into new parts of a community already served by transit) is typically in the range of 0.6 to 1.0, meaning that each 1% of additional service increases ridership by 0.6-1.0%. New bus service in a community typically achieves 3 to 5 annual rides per capita, with 0.8 to 1.2 passengers per bus-mile. Higher first-year ridership occurs in some circumstances, such as university towns or suburbs with rail transit stations to feed. Improved information, easy-to-remember schedules (for example, every half-hour), and more convenient transfers can increase transit use, particularly in areas where service is less frequent.

Demographics

About 12% of U.S. residents use transit at least once during a two month period, and this increases among certain groups (Polzin and Chu, 1999). Ridership tends to be higher for:

- People who cannot drive (people with disabilities, youths, immigrants, etc.)
- People with low incomes.
- Residents of larger cities.
- Commuters to major commercial centers.
- High school, college and university students.
- Employees who are offered financial incentives.
- People who consider driving stressful.

The Transit Performance Monitoring System (TPMS) surveys provide information on transit ridership demographics (FTA, 2002). Phase I and II surveys found the following:

- Most transit trips are made by lower-income household. Lower-income riders (less than $20,000 annual income in 2002) represent 63% of riders in small transit systems, 51% in medium size transit systems, and 41% of riders in large transit systems.
- Most transit trips are made by riders who use transit frequently. About 70% of trips are made by people who use transit at least five days each week. However, a large number of people use transit infrequently, so 70% of people who use transit during the last month use it less than five times a week.
- There is constant turnover of the transit user population. 38% of current transit trips are made by people who have relied on transit for less than one year, and 29% of transit trips are made by people who relied on transit one to four years.
- Work, school (including university and college) and shopping trips account for 75% of all trips.
- Overall, 33% of transit trips made by discretionary riders (people who have the option of driving a car). This increases to 36% in large transit systems.
- Walking is the most common form of access to transit stops. 6.2% of bus riders and 27% of rail transit riders drive to their transit stop. Nearly all transit trips end with a walking link.
- More than half (56%) of transit passengers report that if transit service were unavailable they would have traveled by automobile, either as a driver or passenger. Below is what respondents report they would do if transit service were unavailable:

Drive	23%
Ride with someone	22%
Taxi/Train	12%
Not make trip	21%
Walk	18%
Bicycle	4%

Table 9 shows responses to a national survey of why people use transit. This indicates that many users either cannot drive, but other factors also motivate transit use, including financial savings, avoiding the stress of driving, and environmental concerns.

Table 9 **Reasons for Using Public Transit** (CUTR, 1998)

I Use Public Transit Because…	Portion of Respondents
It is the most convenient way for me.	82%
Costs less than driving.	78%
Do not have access to a car.	74%
Avoids stress of driving on congested roads.	74%
Is better for the environment.	72%
Avoids buying a car.	65%
I don't drive or don't like to drive.	60%
It is faster than a private vehicle.	43%
I can do something else	41%

Land Use Factors

Various land use factors affect transit use ("Land Use Impacts On Transport," VTPI, 2004). Per capita transit ridership tends to increase with city size (see table below), population and employment density, and the quality of the pedestrian environment.

Table 10 **Portion of Residents Using Transit At Least Once A Month** (NPTS, 1995)

City Size (Thousands)	Residents Riding Transit Monthly
Under 250	1.4%
250-499	5.4%
500-999	6.4%
1,000-2,999	10.0%
3,000+	21.0%
Nationwide	11.6%

One study found the elasticity of transit ridership with respect to residential densities to be +0.22 in U.S. urban conditions, meaning that each 1% increase in density increases transit ridership by 0.22% (PBQD, 1996). Destination density (e.g., clustering of employment) tends to have a greater impact on transit ridership than residential density.

Transit ridership tends to increase if more people live and work near transit stops. Bento, et al, (2003) found that each 10% reduction in the distance between homes and the nearest transit stop reduces automobile commute mode split by 1.6 percentage points, and reduces total annual VMT by about 1%. Kuby, Barranda and Upchurch (2004) evaluate various transit station area factors that affect ridership. They find that on average 100 jobs generate 2.3 daily boardings, 100 residents generate 9.3 boardings, 100 park-and-ride spaces generate 77 boardings, each bus generates 123 boardings, and an airport generates 913 boardings. These land use factors should generally be evaluated at a micro-scale (using small transport analysis zones) along a transit corridor or around a transit station.

Some people claim that at least 12 employees or residents (equivalent to about 6 housing units) per acre are needed to justify more than basic transit service, but other factors are as important as density. Strategies such as campus transport management, commute trip reduction programs and parking pricing can significantly increase transit ridership rates, and so justified quality transit services in areas with lower densities. For example, if a comprehensive commute trip reduction program doubles transit ridership rates, an employment center with 6 employees per acre would generate the same transit demand as an area with 12 employees per acre that lacks such a program.

METS Transit Demand Model (IFS, 2001)
METS (MEtropolitan Transport Simulator) is a large computer model of London's transport system. For example, it can predict the demand for car, bus, underground and taxi trips as a function of the cost of the journey and the cost of alternatives. It allows users to test how various changes in transit service quality, fares, parking pricing and vehicle charges would affect traffic congestion and speeds, transit ridership and other travel impacts. It uses default values that simulate transport in London, but it can be modified for any large urban region. METS is available on the Internet through the Virtual Learning Arcade (www.bized.ac.uk/virtual/vla/transport/index.htm).

Type of Transit

There is considerable debate concerning the differences in demand between bus and rail transit (see discussion of bus versus rail transit later). Rail transit is considered more comfortable and prestigious than buses, and so tends to attract more discretionary riders (travelers who would otherwise drive) within a service area (Pushkarev and Zupan, 1977), but a bus network can reach more destinations, providing more comprehensive and direct coverage through a region, and so may attract more riders with a given level of investment (GAO, 2001). Rail passengers appear willing to accept more crowded conditions than bus passengers (Demery and Higgins, 2002).

Litman (2004a) finds that cities with larger rail transit services have significantly higher per capita transit ridership. Baum-Snow and Kahn (2005) found that in "old rail" cities (cities that have well-established rail transit systems in 1970) transit commuting declined from 30% in 1970 to 23% in 1990. In "new rail" cities (cities that build rail transit lines between 1970 and 1990), transit commuting declined from 8% to 6% during this period. In cities without rail transit commuting declined from 5% to 2%. Transit use in all three samples remained relatively unchanged between 1990 and 2000. They conclude that rail transit, including expanded and new services, does tend to increase total transit ridership if local land use is supportive.

Transit Impact Categories

This section describes various types of transit impacts (benefits and costs), and how they can be measured. For additional information on these impacts see Litman, 2003.

Transit Expenditures

Most direct transit service costs can be obtained from transit agency budgets. Table 11 summarizes U.S. transit service expenses and revenues. Detailed information is available on individual transit agencies. Expenses are divided into *capital* (facilities, equipment and other durable goods) and *operation* (labor, fuel and maintenance). Some costs, such as Park&Ride lots, special roadway facilities such as bus pullouts, and increased road maintenance due to bus traffic may be borne by other government agencies.

Table 11 **2002 U.S. Public Transit Expenses and Revenues** (APTA, 2003)

	Bus	Trolley Bus	Heavy Rail	Commuter Rail	Demand Response	Light Rail	Other	Totals
Capital Expenses (m)	$3,028	$188	$4,564	$2,371	$173	$1,723	$253	$12,301
Operating Expenses (m)	$12,586	$187	$4,268	$2,995	$1,636	$778	$457	$22,905
Total Expenses (m)	$15,613	$374	$8,832	$5,366	$1,809	$2,502	$710	$35,206
Average Fare Per Trip	$0.71	$0.51	$0.93	$3.50	$2.34	$0.67	$1.14	$0.92
Fare Revenues (m)	$3,731	$60	$2,493	$1,449	$185	$226	$132	$8,275
Subsidy (Total Exp. - Fares)	$11,882	$315	$6,339	$3,917	$1,624	$2,276	$577	$26,931
Vehicle Revenue Miles (m)	1,864	13	604	259	525	60	102	3,427
Passenger Miles (m)	19,527	188	13,663	9,450	651	1,432	1,034	45,944
Avg. Veh. Occupancy	10.5	14.1	22.6	36.5	1.2	23.9	10.1	13.4
Avg. Trip Distance (miles)	2.8	8.7	4.5	1.6	0.2	5.6	1.1	2.6
Unlinked Trips (m)	5,268	116	2,688	414	79	337	116	9,017
Total Expend. Per Pass. Mile	$0.80	$1.99	$0.65	$0.57	$2.78	$1.75	$0.69	$0.77
Fare Rev. Per Pass. Mile	$0.19	$0.32	$0.18	$0.15	$0.28	$0.16	$0.13	$0.18
Subsidy Per Pass. Mile	$0.61	$1.68	$0.46	$0.41	$2.50	$1.59	$0.56	$0.59
Percent Subsidy	76%	84%	72%	73%	90%	91%	81%	76%

m=million

Costs and revenues can vary significantly within a particular transit system, line or route. Various methods can be used to calculate the marginal cost of a particular trip (Taylor, Iseki and Garrett, 2000). In general, urban-peak transit has higher costs, but also has higher load factors and so tends to have greater cost recovery (lower subsidies) per passenger-mile compared with off-peak and suburban/rural transit service. The costs of a particular transit improvement can vary widely depending on conditions, such as whether rights-of-way and equipment already exist or must be acquired. If a transit service already exists, it is sometimes possible to increase capacity at minimal marginal cost.

Measuring Transit Service Costs

Transit service costs can usually be obtained from transit agencies. Costs for specific transit programs and projects require analysis of the particular situation. For comparison it is usually helpful to calculate costs per passenger-mile or passenger-trip.

Impacts on Existing Transit Users

It is important to take into account impacts on existing users when evaluating changes in transit service and fares. This refers to trips that would be made by transit regardless of whether a new program or policy is implemented – additional transit trips made by existing users are considered in the *mobility benefits* section below.

Measuring Existing User Impacts

Financial impacts on existing users can be measured directly. For example, a new $25 per month transit subsidy provided to 100 current transit commuters represents a $30,000 annual benefit to that group. A 25¢ fare increase that applies to 1,000,000 annual fares represents an annual cost of $250,000 to existing riders.

Some service quality changes can be measured with conventional transportation evaluation techniques, such as applying standard travel time values ("Travel Time Costs," Litman, 2003). Travel time is generally valued at half average wage rates, and two or three times higher for time spent driving in congestion, walking to a transit stop, waiting for a bus, or traveling in unpleasant conditions such as in a crowded vehicle, as discussed later in this report. A value of about $8 per hour is appropriate for transit passengers who are comfortable, and a higher value of $16 per hour is appropriate for time spent walking, waiting or riding in a crowded transit vehicle.

For example, a bus priority strategy that saves transit riders 10,000 hours annually in travel time can be valued at $80,000 if all passengers have a seat, or $120,000 if half of those passengers are standees for whom travel time savings values are doubled. Similarly, benefits to existing users of increased transit frequency or coverage can be calculated based on their reduced average walking and waiting time.

A service improvement that increases rider comfort, such as reducing crowding, can also be measured by reducing the cost per hour of passenger travel time. For example, if a transit service improvement reduces crowding for 5,000 passenger-hours, the benefit to these riders can be considered worth $40,000, because it eliminates the travel time cost premium associated with uncomfortable conditions, reducing travel time costs from $16 to $8 per hour.

Of course, these values should be calibrated and adjusted to reflect specific conditions, taking into account local wages and preferences, or to be consistent with other analysis models. Other service quality impacts may require more research to measure. For example, to quantify the value to existing users of improved use information or rider security it may be necessary to survey riders to determine how many are affected (the number who use a new information service or travel on vehicles with improved security) and the value they place on such improvements.

Mobility Benefits

Mobility benefits result from additional personal travel that would not otherwise occur, particularly by people who are *transportation disadvantaged*, that is, they cannot drive due to physical, economic or social constraints.

Public transit currently serves a relatively small portion of trips in most communities, but the trips it serves tend to be high value to users and society. Transit provides *basic mobility* by helping people reach important activities such as medical services, education and employment. This is particularly true of Demand Response service riders, who have moderate to severe disabilities that limit their mobility, and often are unable to use other travel options, such as walking, cycling or conventional taxis.

Transit is an important travel mode for low- and middle-income non-drivers. For example, a household earning $20,000 annual income typically spends about $2,500 per year on transport. On this budget, a non-driver in a community with no transit service can only afford about five taxi trips per week (resulting in an inferior level of mobility). A non-driver who lives in a community with good transit service can purchase a monthly transit pass and still afford two or three taxi trips per week, providing a relatively high level of mobility, although still inferior to a motorist.

Several categories of mobility benefits are described below. Some of these categories may overlap. They tend to differ in their nature and distribution (who benefits), and so reflect different perspectives. For example, *user benefits* tend to interest residents and *public service support* interests public officials.

User Benefits

This refers to direct benefits to users from increased access to services and activities, including medical services, economic benefits from schooling and employment, enjoyment from being able to attend social and recreational activities, and financial savings from being able to shop at a wider range of stores. By improving access to education and jobs transit can increase people's economic opportunities.

People living near public transit service tend to work more days each year than those who lack such access (Sanchez, 1999), and many transit commuters report that they would be unable to continue at their current jobs or would earn less if transit services were unavailable (Crain & Associates, 1999). Similarly, a significant portion of students depend on public transit for commuting to schools and colleges, so a reduction in transit services can reduce their future productivity. A survey of adults with disabilities actively seeking work found 39% considered inadequate transport a barrier to employment (Fowkes, Oxley and Henser, 1994). Increased employment by such groups provides direct benefits to users and increases overall productivity. Economic benefits to businesses are discussed in the Productivity Benefits section.

Public Service Support

Transit can support government agency activities and reduce their costs. For example, without transit services some people are unable to reach medical services, sometimes resulting in more acute and expensive medical problems. Transit services can help reduce welfare dependency and unemployment (Multisystems, et al, 2000). Transit access can affect elderly and disabled people's ability to live independently, which can reduce care facility costs. As a result, a portion of public transit subsidies may be offset by savings in other government budgets.

Equity Benefits

Transit helps achieve community equity objectives. It increases economic and social opportunities for people who are economically, physically and socially disadvantaged, and helps achieve equity objectives, such as helping physically and economically disadvantaged people access public services, education and employment opportunities. Transit helps reduce the relative degree that non-drivers are disadvantaged compared with motorists.

Option Value

Transit services provide *option value*, referring to the value people place on having a service available even if they do not currently use it (ECONorthwest and PBQD, 2002). Transit can provide critical transportation services during personal and community-wide emergencies, such as when a personal vehicle has a mechanical failure, or a disaster limits automobile traffic. This is similar to ship passengers valuing lifeboats, even when they don't use them.

Measuring Mobility Benefits

The value to users of increased mobility that results from price changes (fare reductions, targeted discounts, parking cash-out) can be calculated using the "rule of half," which involves multiplying half the price change times the number of trips that increase or decrease, which represents the midpoint between the old price and the new price, and therefore the average incremental value of those trips (Small, 1999). For example, if a 50¢ fare discount increases transit ridership by 10,000 trips, the value to users of these additional trips can be considered to be $2,500 (10,000 x 50¢ x ½).

In most situations the maximum value to users of mobility benefits is their savings relative to the same trips by taxi, which represents a more costly but nearly universal alternative. Cheaper alternatives are sometimes available, such as walking, cycling, ridesharing or telecommuting, so actual average savings are probably about half taxi savings, assuming a linear curve of alternative travel option costs. Transit fares average about 15¢ per passenger-mile, while local taxi service costs average about $2.25 per vehicle-mile. This implies about $1.00 net benefits per passenger-mile when a typical bundle of alternative mode trips shift to transit.

Demand response services tend to provide significantly greater mobility benefits because users face greater transportation constraints, and alternatives options tend to be more costly. Many demand response clients are unable to walk, and some cannot be accommodated by conventional taxis because they have large mechanical wheelchairs or other special needs. As a result, mobility benefits can be doubled or tripled when evaluating demand response services.

Passengers who shift from a current transit route to a new route can be assumed to benefit from increased convenience and time savings, typically from reduced walking. This can be calculated from user surveys or estimated at $1-3 value of travel time savings per trip, assuming 5-10 minute average time savings per trip.

Leigh, Scott & Cleary (1999) developed a method for quantifying a community's *mobility gap*, defined as the amount of additional transit service required for households without a motor vehicle to have a comparable level of mobility as vehicle owning households. This is a conservative estimate because it does not account for unmet mobility needs of non-drivers in vehicle-owning households. Only about a third of transit needs are currently being met in typical areas they evaluated, indicating a level of service (LOS) rating D, based on ratings shown in Table 12. The approach can be used to predict the LOS rating that will occur under various transit planning and investment scenarios.

Table 12 **Transit Level Of Service Ratings** (Leigh, Scott & Cleary, 1999, p. VIII-3)

Portion of Demand Met	Transit Level-Of-Service
90% or more	A
85-89%	B
50-74%	C
25-49%	D
10-24%	E
Less than 10%	F

A variety of factors can be considered when evaluating a community's transit needs and the mobility gap between residents who drive and those who do not. These include vehicle ownership (residents of households that do not own a motor vehicle tend to rely significantly on transit), age (residents in the 10-21 and 65+ year age ranges tend to rely on transit more than those 21-65), income (lower-income people tend to use transit more than higher-income people), race and residency status (non-white and immigrant residents tend to rely more on transit than white and U.S. born residents).

EcoNorthwest and PBQD (2002) describe methods of calculating *option value* based on consumers' willingness to pay to maintain a mobility option that they use infrequently. This involves assigning an additional value to each transit trip made by an infrequent user, taking into account the cost to consumers of each trip, the volatility of demand and the expected frequency of such trips. In typical conditions this appears to be in the range of $1-10 annual per resident who expects to use transit a few times each year.

The table below summarizes the four categories of transit mobility benefits and describes how they can be measured. Mobility benefits are affected by the degree to which transit service is available to those who need it and the additional mobility it provides. For example, a transit improvement that increases the number of households and worksites within a quarter-mile of bus service, or which increases the number of trips made by people with disabilities or low incomes, can be considered to increase mobility benefits.

These benefits sometimes overlap; for example, some user and public service benefits can also be counted as equity benefits.

Table 13 **Comparing Equity and Efficiency Objectives**

Category	Description	How It Can Be Measured
User Benefits	Direct user benefits from the additional mobility provided by public transit.	Rider surveys to determine the degree that users depend on transit, the types of trips they make, and the value they place on this mobility.
Public Service Support	Supports public services and reduces government agency costs.	Consultation with public agency officials, and surveys of clients, to determine the role transit provides in supporting public service goals.
Equity	Degree to which transit helps achieve equity objectives such as basic mobility for physically, economically and socially disadvantaged people.	Portion of transit users who are economically, socially or physically disadvantaged, the importance of mobility in ameliorating these inequities, and the value that society places on increased equity.
Option Value	Benefits of having mobility options available in case it is ever needed.	Transit service coverage, ability of transit to serve in emergencies, the value that society places on mobility insurance. EcoNorthwest and PBQD (2002) describes ways to quantify transit option value.

Public transit provides several types of mobility benefits. These are affected by the degree that transit service is available to non-drivers, and the amount of increased mobility it provides.

Efficiency Benefits

Efficiency benefits consist of savings and other benefits that result when transit substitutes for automobile travel. These include vehicle cost savings, avoided chauffeuring, congestion reductions, parking cost savings, increased safety and health, energy conservation and pollution emission reductions.

These benefits are affected by the magnitude and type of automobile travel reduced. For example, urban-peak automobile travel reductions tend to provide greater benefits than reductions in urban off-peak or rural travel, due to greater reductions in traffic congestion, parking costs and other costs. As a city grows, these benefits become increasingly important as a cost effective way to reduce traffic congestion and parking problems, particularly to major commercial and employment centers such as downtown. These benefits increase if transit improvements and incentives are designed to attract discretionary riders (people who have the option of driving).

Except in large cities, most transit system are designed primarily to provide basic mobility rather than efficiency benefits. Buses operate at times and locations where demand is low, and there are few incentives to attract discretionary travelers to transit. As a result, average occupancy is relatively low, averaging about 5.2 passengers per bus-mile (excluding demand response services), and so may appear inefficient when evaluated based on average operating costs, energy consumption or pollution emissions per passenger-mile. But transit demand tends to be concentrated on the corridors with the greatest traffic congestion and parking problems, so transit can provide benefits in these areas. The incremental cost of accommodating additional passengers is low, so strategies which increase average transit vehicle occupancy increase efficiency benefits. Put differently, if buses have empty seats, there is minimal cost and large potential benefits if they can be filled by travelers who would otherwise drive.

The efficiency benefits of transit improvements reflect the factors described below.

- Strategies that increase bus mileage on routes with low load factors (for example, increasing mileage on suburban and off-peak routes) may increase some costs, such as total energy consumption and pollution emissions.
- Strategies that shift travel from automobile to transit while increasing average vehicle occupancies (that is, they help fill otherwise empty buses) tend to reduce overall costs.
- Strategies that improve transit vehicle performance (for example, retrofitting older diesel buses with cleaner engines or alternative fuels, or creating busways that reduce congestion delays) tend to reduce specific costs.
- Strategies that create more accessible land use patterns and less automobile-dependent transportation systems, provide large benefits by reducing overall per capita vehicle travel.

Specific efficiency benefits and how they can be measured are discussed below.

Vehicle Cost Savings
Shifting travel from automobile to transit Vehicle Cost savings to consumers. The magnitude of these savings depends on several factors, including the type of mileage reduced and whether vehicle ownership declines ("Vehicle Costs," Litman, 2003).

At a minimum, shifting from driving to transit saves fuel and oil, which typically total about 10¢ per vehicle-mile reduced. In addition, depreciation, insurance and parking costs are partly variable, since increased driving increases the frequency of vehicle repairs and replacement, reduces vehicle resale value, and increases the risks of crashes, traffic and parking citations. These additional mileage-related costs typically average 10-15¢ per mile, so cost savings total 20-25¢ per mile reduced. Savings may be greater under congested conditions, or where transit users avoid parking fees or road tolls.

Consumers save more if transit allows vehicle ownership reductions. For example, if improved transit services allow 10% of users to reduce their household vehicle ownership (e.g., from two vehicles to one), the savings average $300 annually per user (assuming a second car has $3,000 annual ownership costs), or 6¢ per transit travel passenger-mile (assuming 20 miles of transit travel a day, 250 days per year) in addition to vehicle operating cost savings. Reduced vehicle ownership can reduce residential parking costs. Cumulative savings can be large. McCann (2000) found that households in communities with good transit use save an average of about $3,000 annually on transportation costs. Litman (2004) found annual transportation cost savings of about $1,300 per household in cities with well-established rail transit systems compared with cities that lack rail.

Measuring Vehicle Cost Savings
Table 14 summarizes various categories of savings that can result from reduced automobile ownership and use. These savings typically total 30¢ per off-peak vehicle-mile and 40¢ per urban-peak vehicle-mile when automobile travel shifts to public transit. Other researchers recommend using 40-50¢ per vehicle mile reduced (ECONorthwest and PBQD, 2002). Even greater savings result if transit oriented development causes a significant number of households to reduce their vehicle ownership.

Table 14 **Potential Vehicle Cost Savings** ("Vehicle Costs," VTPI, 2003)

Category	Description	How It Can Be Measured	Typical Values
Vehicle Operating Costs	Fuel, oil and tire wear.	Per-mile costs times mileage reduced.	10-15¢ per vehicle-mile. Higher under congested conditions.
Long-Term Mileage-Related Costs	Mileage-related depreciation, mileage lease fees, user costs from crashes and tickets.	Per-mile costs times mileage reduced.	10¢ per vehicle-mile.
Special Costs	Tolls, parking fees, Parking Cash Out, PAYD insurance.	Specific market conditions.	Varies.
Vehicle Ownership	Reductions in fixed vehicle costs.	Reduced vehicle ownership times vehicle ownership costs.	$3,000 per vehicle-year.
Residential Parking	Reductions in residential parking costs due to reduced vehicle ownership.	Reduced vehicle ownership times savings per reduced residential parking space.	$100-1,200 per vehicle-year.

Reducing automobile travel can provide a variety of consumer savings. (2001 U.S. dollars).

Avoided Chauffeuring

Chauffeuring refers to additional automobile travel specifically to carry a passenger. It can also include taxi trips. It excludes Ridesharing, which means additional passengers in a vehicle that would be making a trip anyway. Some motorists spend a significant amount of time chauffeuring children to school and sports activities, family members to jobs, and elderly relatives on errands. Such trips can be particularly inefficient if they require drivers to make an empty return trip, so a five-mile passenger trip produces ten miles of total vehicle travel.

Drivers sometimes enjoy chauffeuring, for example, when it gives busy family members or friends time to visit. However, chauffeuring can be an undesirable burden, for example, when it conflict with other important activities. Transit service allows drivers to avoid undesirable chauffeuring trips while still providing enjoyable trips.

Measuring Chauffeuring Cost Savings

This benefit can be estimated based on the number of chauffeured automobile trips shifted to transit, times vehicle cost and driver travel time savings. Rider surveys and experience with service disruptions indicate that in typical conditions, 10-40% of transit trips would otherwise be made as automobile passengers, and about half of these are rideshare trips (passengers in vehicles that would be making the trip anyway), meaning that 5-20% of transit trips substitute for chauffeured trips. Travel and rider surveys can help determine the portion of such trips in a particular situation.

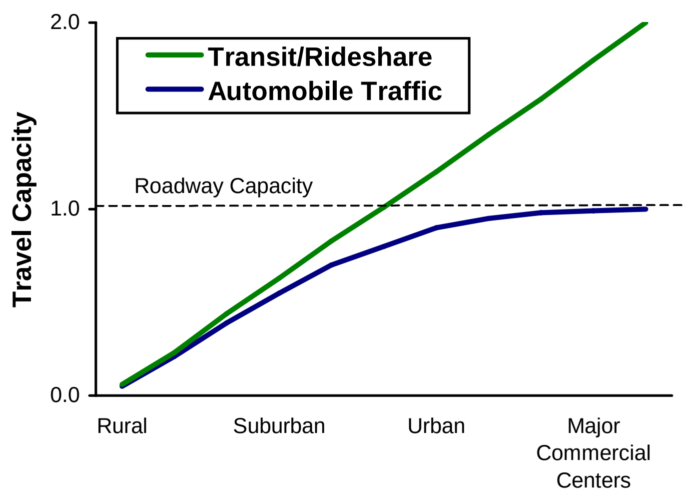
Assuming these average 5 miles in length per trip and take 20 minutes (including waiting time and empty backhauls), travel time costs average $12.00 per driver hour (assuming a mixture of high- and low-stress driving conditions), driver travel time savings are about $4.00 per chauffeured trip avoided or 80¢ per passenger-mile shifted to transit, including 25¢ per mile vehicle costs total $5.25 per trip, or $1.05 per chauffeured vehicle-mile. Avoided taxi trips cost savings can be based on average taxi fares for those trips, which average about $2.25 per mile.

Congestion Reduction

Traffic congestion consists of the incremental delay, stress, vehicle operating costs and pollution that each additional vehicle imposes on other road users. A typical urban street lane can carry up to 500-1,000 vehicles per hour, and a typical highway lane can carry up to 1,800-2,300 vehicles per hour. Congestion develops when traffic volumes approach these limits. When roads are full, even modest mode shifts can provide significant congestion reductions. For example, reducing congested roadway traffic volumes 5% can reduces delays 10-30%.

As cities grow, transit and ridesharing play an increasingly important role in providing mobility and reducing congestion and parking problems, as illustrated in Figure 3. Buses typically carry 40-60 passengers under congested urban conditions, and rail transit even more. Peak period transit service that carries 4,000 passengers per hour on highways or 1,000 passengers per hour on surface streets is equivalent to an additional traffic lane, assuming half of transit users would otherwise drive. This equals 20 to 80 buses per hour.

Figure 3 **Urbanization Impacts on Transit Use**



When roadways approach their maximum traffic capacity, transit and ridesharing carry an increasing portion of person-trips. In major commercial centers, a significant portion of commuters travel by transit, vanpools or carpools.

Special care is needed to accurately evaluate transit congestion reduction impacts ("Congestion Costs," Litman, 2003). Traffic congestion tends to increase with city size because there are more vehicles within a given area. Transit service and ridership also increase with city size, so cities with more transit tend to have worse congestion than those with less transit, but it would be wrong to conclude that transit *causes* congestion, or that congestion problems would be as bad if transit service did not exist.

Once a roadway reaches capacity even a small reduction in volume can significantly reduce delays. For example, a 5% reduction in peak-hour traffic volumes on a road at 90% capacity can reduce delay by 20% or more. Transit tends to be most effective on congested urban corridors where travel is concentrated. As a result, transit can provide significant congestion reduction benefits, even if it only carries a small portion of total regional travel. Expanding such urban roadways tends to provide little long-term congestion reduction benefit, due to latent demand, and it often increases other transport problems such as downstream congestion. Planners recognize the increasing importance of transit to address roadway congestion problems (TTI, 2003).

Congestion reduction benefits can be difficult to evaluate because urban traffic tends to maintain equilibrium: traffic volumes grow until congestion delays discourage additional peak-period trips. As a result, roadway spaces created when some travelers shift from driving to transit may soon be filled with generated demand: the benefit is the additional car trips accommodated rather than a long-term reduction in congestion (Litman, 2001). However, transportation improvements that increase transit and ridesharing convenience, speed, comfort, affordability and prestige, or increase the cost of peak-period driving, tend to attract discretionary riders and therefore reduce traffic congestion. These strategies can change the point of equilibrium, reducing congestion delays for all road users. Grade separated transit is particularly effective, as described in the box below.

How Transit and HOV Reduces Traffic Congestion

When a road is congested, even small traffic volume reductions can significantly increase traffic speeds. For example, on a highway lane with 2,000 vehicles per hour a 5% reduction in traffic volumes will typically increase traffic speeds by about 20 miles per hour and eliminate stop-and-go conditions (TRB, 1994). Similar benefits occur from traffic volume reductions on congested surface streets.

Urban traffic congestion tends to maintain equilibrium. If congestion increases, people change route, destination, travel time and mode to avoid delay, and if it declines they take additional peak-period trips. Reducing the point of equilibrium is the only way to reduce long-term congestion. The quality of travel alternatives has a significant effect on the point of congestion equilibrium: If alternatives are inferior, few motorists will shift mode and the point of equilibrium will be high. If alternatives are attractive, motorists are more likely to shift modes, reducing the equilibrium. Improving travel options can therefore increase travel speeds for both those who shift modes and those who continue to drive.

To attract discretionary riders (travelers who have the option of driving), transit must be fast, comfortable, convenient and affordable. Grade-separated transit (such as rail on separate right-of-way or busways) provides a speed advantage that can attract discretionary riders. When transit is faster than driving, a portion of travelers shift mode until the highway reaches a new congestion equilibrium (that is, until congestion declines to the point that transit is no longer faster). As a result, the faster the transit service, the faster the traffic speeds on parallel highways. Several studies find that door-to-door travel times for motorists tend to converge with those of grade-separated transit (Mogridge, 1990; Lewis and Williams, 1999). The actual number of motorists who shift to transit may be relatively small, but is enough to reduce delays. Congestion does not disappear, but it never gets as bad as would occur if the parallel grade-separated transit service did not exist. Comparisons between cities indicate that total congestion delay tends to be lower in areas with good transit service (STPP, 2001; Litman, 2004a).

Shifting traffic from automobile to transit on a particular highway not only reduces congestion on that facility, it also reduces vehicle traffic discharged onto surface streets, providing "downstream" congestion reduction benefits. For example, when a highway widening with transit improvements, the analysis should account for the additional congestion on surface streets that would be avoided if the transit improvement attracts highway drivers out of their cars.

One indication of transit's congestion reduction benefits is the effect of service disruptions. Congestion usually increases when service on major urban corridors fails due to financial, labor, or technical problems. For example, in 2003, a 5-week-long transit strike in Southern California significantly increased regional traffic congestion, despite the fact that transit ridership there is relatively low compared with other large cities. Short-term impacts are often minimized because travelers temporarily adjust to reduce peak-period trips, but after a few days congestion usually increases significantly while mobility declines. The cost is therefore a combination of increased congestion delays, and disruptions to travelers who forego trips or make other adjustments.

Studies by Castelazo and Garrett (2004) and by Winston and Langer (2004) indicate that traffic congestion often declines in a city as rail transit mileage expands (see discussion in Litman, 2005a). Modeling by Laval, Cassidy and Herrera (2004) indicates that a disruption of the Bay Area Rapid Transit (BART) system would cause severe traffic problems on area roads. Without BART service, morning congestion on the Bay Bridge westbound would create backups stretching 26 miles with vehicles traveling as slowly as 9 miles per hour. In the afternoon, heading east, the Bay Bridge backup would stretch 31 miles with an average travel speed of 11 miles per hour. "We found that the peak morning rush hour will go from two hours starting at 7 a.m. to a staggering seven hours, so half the workday would be gone by the time drivers step out of their cars," said Michael Cassidy, UC Berkeley professor of civil engineering and co-author of the report.

Nelson, et al (2006) used a regional transport model to estimate Washington DC transit system benefits to users, and congestion-reduction benefits to motorists. They found that rail transit generates congestion-reduction benefits that exceed rail subsidies, and the combined benefits of rail and bus transit significantly exceeds total transit subsidies. Their study overlooked other benefits such as parking cost savings, crash and emission reduction benefits, and so understates total social benefits.

Busways can also reduce traffic congestion on parallel roads. A study by researchers at the California Center for Innovative Transportation at the University of Berkeley comparing traffic conditions on the 101 Freeway in Southern California before and two months after implementation of the Orange Line busway in October 2005 determined that peak hour traffic through the south San Fernando Valley sped up about 7% — from an average 43 mph to 46 mph, and the amount of time that morning commuters waste being stuck in congestion — defined as traffic slower than 35 mph — has declined about 14%. The study also found that congestion on the heavily traveled freeway is now beginning about 11 minutes later than before the Orange Line opened, with the onset of the morning slows shifting on average from 6:55 a.m. to 7:06 a.m. (Liu, 2005)

It can be argued that transit congestion reductions are offset by slower speeds for transit riders. Bus transit trips average 12.7 miles per hour, light rail 15.4 mph, heavy rail 20.3 mph, and commuter rail 31.6 mph (see table below), while automobile travel averages about 35 mph overall (NPTS, 1999). Transit trip speeds are particularly low when measured door-to-door, taking into account time spent walking and waiting. However, several factors must be considered when comparing transit and automobile speeds.

Table 15 **Average Transit Speeds** (APTA, 2002)

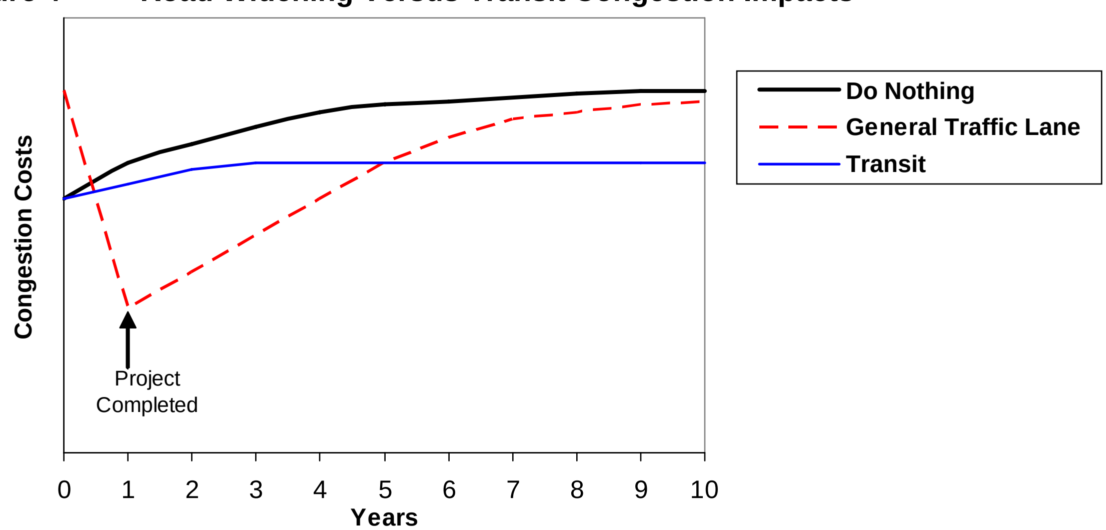
	Bus	Light Rail	Heavy Rail	Commuter Rail
Vehicle Revenue Miles (millions)	1,864	60	604	259
Vehicle Revenue Hours (millions)	146	3.9	29.8	8.2
Average Miles Per Hour	*12.8*	*15.4*	*20.3*	*31.6*

Bus and light rail speeds tend to be relatively low, because they generally travel in traffic, and so are delayed by congestion, and make frequent stops. Rail transit speeds tend to be much higher.

But *average* travel speeds are irrelevant, what matters is their travel speeds on a particular corridor. Automobile speeds tend to be lower and commute travel times higher in large cities where transit (particularly rail transit) is most common. For example, although automobile commute speeds average 39 mph in rural areas, they average only 33 mph in cities with more than 3 million residents (NPTS, 1999), and are even lower on the congested urban corridors where transit commuting is most common. Where transit has separate right-of-way, transit trips are often faster than driving.

Even if transit travel takes more time than driving, travelers may not consider this an additional cost because it reduces stress (see "Travel Time Impacts" section later in this report). Passengers using high-quality transit (safe, clean, comfortable and reliable vehicles), can read, work and rest. If quality transit is available, travelers will select transit or driving based on their needs and preferences (Wener, Evans and Boately, 2004). This maximizes transport system efficiency (since shifts to transit reduce congestion) and consumer benefits (since consumers can choose the option they prefer).

Figure 4 **Road Widening Versus Transit Congestion Impacts**



After a general traffic lane is completed congestion declines, but grows rapidly due to generated traffic. Grade separated transit and HOV systems initially provide less congestion reduction, but their benefits increase as roadway congestion grows, so they become relatively faster.

Highway and transit improvements provide congestion reduction benefits at different rates of time, as illustrated in Figure 4. If travel demand is growing and no action is taken, congestion will increase until it limits further peak-period vehicle trips. Adding a general traffic lane increases congestion during the construction period, then congestion decline significantly, but traffic grows over time so congestion eventually returns to its previous level. Grade-separated transit may initially seem to provide little congestion reduction, but roadway congestion increases much less than would otherwise occur because increased highway delays makes transit faster than driving and so attracts an increasing portion of travelers. Although roadway congestion never disappears, it never gets as bad as would otherwise occur. As a result, shorter-term analysis tends to favor roadway expansion, while longer-term analysis tends to favor transit improvements.

Analysis of TTI congestion cost data by Winston and Langer (2004) shows that both motorist and truck congestion costs decline as rail transit mileage expands in a city, but congestion costs increase with bus transit mileage, apparently because buses are less effective at attracting motorists, contribute to traffic congestion themselves, and do little to increase land use accessibility. However, strategies that improve either rail or bus transit speed, convenience, comfort and prestige, and therefore attract large numbers of discretionary urban-peak travelers, may reduce congestion.

Most congestion cost studies only consider delays to motor vehicle users. Roads and vehicle traffic can also delay non-motorized travel, called the “barrier effect” or “severance” (Litman, 2003). Such costs can be significant in urban areas. Urban streets often have as many pedestrians as motorists. This suggests that transit improvements that reduce surface street traffic volumes provide additional benefits by improving pedestrian mobility and safety, which are overlooked in conventional congestion cost analysis.

Measuring Vehicle Congestion Reduction Benefits

There are several ways to measure congestion reduction benefits that result from reduced vehicle traffic (TRB, 1997). One approach is to model total passenger travel time with and without a transit program, and calculate the travel time and vehicle operating cost savings (ECONorthwest and PBQD, 2002). The Texas Transportation Institute uses a similar method to calculate congestion reduction value of transit (TTI, 2003). Another approach is to calculate the costs of increasing roadway capacity to achieve a given congestion reduction, and divide that by the number of peak-period vehicle-miles. These methods require modeling each option, and current transportation models are often not very accurate at predicting the travel impacts of a transit project.

An easier approach is to assign a dollar value to reduced vehicle travel, usually estimated at 10-30¢ per urban-peak vehicle-mile, and more under highly congested conditions (Litman, 2003). Congestion benefits should reflect net impacts, that is, the reduction in automobile trips minus any additional transit impacts. Under typical conditions buses impose congestion costs equivalent to 1.5 cars on highway and 4.5 cars on surface streets, so net benefits occur when more than about three trips shift from automobile to transit. For example, if a bus carries 16 passengers under urban-peak conditions, and 8 of the passengers would otherwise travel by automobile (either driving themselves or chauffeured), the congestion reduction benefit is (8-3) x $0.25 = $1.25 per vehicle-mile.

Where transit provides significant travel time savings compared with driving on parallel highways (for example, with grade-separated rail transit or busways) it is possible to calculate the resulting reduction in congestion delays. For example, if average door-to-door travel times by automobile are 30-minutes per peak-period trip, and a proposed transit service will provide 25-minute average trip times, the transit service can be expected to reduce average travel times by approximately 5-minutes per trip for all users. Travel time cost values can be applied ("Travel Time Costs," Litman, 2003).

How congestion is measured affects evaluation conclusions. Indicators that measure the *intensity of congestion* (such as roadway Level-of-Service) or the portion of *driving* that occurs under congested conditions, ignore the congestion reduction benefits of travel by alternative modes and more accessible land use. These indicators imply that congestion declines if uncongested vehicle-mileage increases. Congestion impact evaluation also depends on the scale of analysis. For example, transit oriented development may increase local congestion (within a few blocks), because it increases neighborhood density, but regional congestion can decline due to less traffic between neighborhoods. Indicators of *per-capita* congestion costs recognize the congestion reduction benefits of improved transport alternatives (STPP, 2001). Measuring congestion in terms of roadway level-of-service, and failing to consider the effects of generated traffic tends to exaggerate the congestion reduction benefits of urban roadway capacity expansion, since within a few years latent demand fills much of the added capacity (Litman, 2001).

A particular transit improvement may avoid the need for a specific highway project, in which case congestion reduction benefits can be calculated based on facility cost savings. For example, if roadway capacity expansion costs average $3.5 million per lane-mile, which can carry 2,000 peak-period vehicles, this averages about 37¢ per additional peak-period vehicle-mile (based on a 7% discount rate over 20 years, 255 annual commute days), plus about 3¢ per mile in operations expenses. Transit services that defer or avoid the need to expand road capacity by attracting 1,000 daily peak-period automobile trips on a 5-mile stretch provide $510,000 annual benefits (40¢ x 1,000 x 5 x 255 days).

Measuring Pedestrian Delay Reduction Benefits

Studies described in "Evaluating Nonmotorized Transport," (VTPI, 2003) and "The Barrier Effect" (Litman, 2003) indicate that barrier effect costs average about 2¢ per urban-peak car-mile, and about 1.3¢ under urban off-peak conditions. As with vehicle congestion, a bus represents about 3 passenger car equivalents.

Combined Vehicle and Pedestrian Congestion Costs

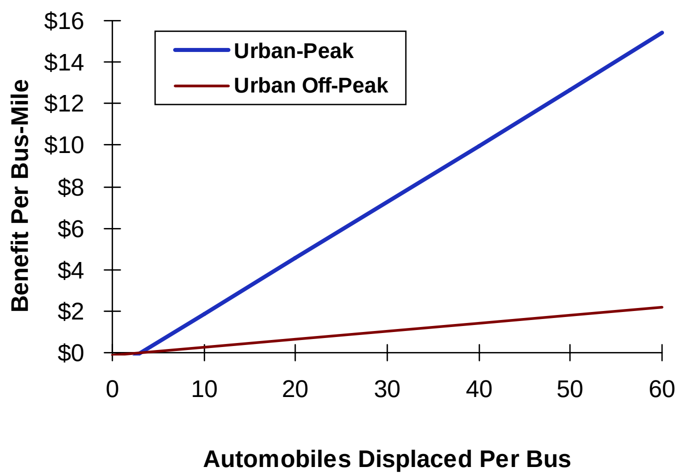
Table 16 shows the recommended congestion cost values.

Table 16 **Recommended Congestion Cost Values** (Per Vehicle-Mile)

	Urban Peak	**Urban Off-Peak**
Vehicle Congestion Costs	25¢	2.5
Pedestrian Congestion Costs	2¢	1.3¢
Total Congestion Costs	*27¢*	*3.8¢*

Figure 5 illustrates the net congestion cost reduction benefits provided by shifts from automobile to bus transit under urban-peak and urban off-peak conditions.

Figure 5 **Congestion Reduction Benefits**



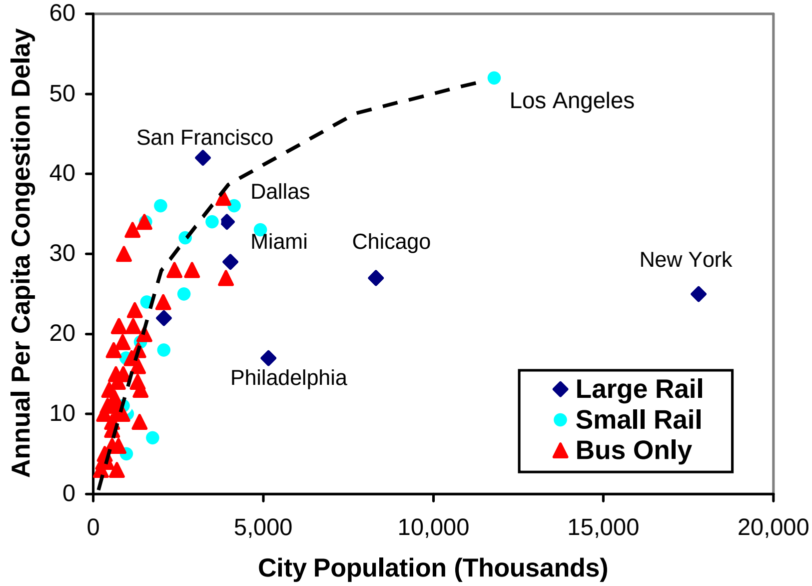
This figure indicates the net vehicle and pedestrian congestion reduction benefits caused by shifts from automobile to buses under urban-peak and urban off-peak conditions.

Buses typically carry 40-60 passengers under congested conditions (i.e., urban-peak travel in the primary travel direction), and rail transit vehicles even more (see Beamguard, 1999 for photos comparing the road space used by bus patrons, motorists and cyclists). Peak period transit service that carries 4,000 passengers an hour on highways or 1,000 passengers an hour on surface streets is approximately equal to one additional traffic lane, assuming that half of transit passengers would otherwise drive an automobile. This equals 20 to 80 buses per hour carrying an average of 50 passengers.

An indication of the congestion reduction benefit of transit is the significant increases in traffic congestion that often occur during transit strikes, even if only a small portion of transit passengers shift to driving alone (van Exel and Rietveld, 2001). For example, a 1974 Los Angeles bus strike caused a 5-15 minute increase in congestion delay on one major freeway, although less than 3% of total regional trips were previously made by transit, and only about half of transit users shifted to driving (ibid).

Even a relatively small shift from driving to grade-separated transit can reduce roadway congestion delays. Comparisons between cities indicates that total traffic congestion delay tends to be lower in areas with good transit service, even though transit only carries a relatively small portion of total regional passenger travel (STPP, 2001; Litman, 2004a).

Figure 6 **Traffic Congestion** (Litman, 2004a)



In cities that only have bus transit or relatively small rail systems traffic congestion delay tends to increase with city size, as indicated by the dashed curve. But cities with large, well-established rail transit systems do not follow this pattern. They have substantially lower congestion costs compared with comparable size cities. As a result, New York and Chicago have about half the per capita congestion delay as Los Angeles.

Commuters Strike Out Without RTD
by Diane Carman, *Denver Post* Staff Columnist, 15 April 2006

At the risk of sounding insensitive to the striking workers' families living without paychecks or the folks who had to cancel appointments because they didn't have a ride to the doctor's office, a week without RTD was a good thing for Denver. Let's face it, there's nothing like a work stoppage to focus our attention on things we take for granted.

So what did the metro area learn from a week without RTD, I mean except for the numbing realization that gloves are a critically important accessory when bicycling to work in 40-degree weather?

Lesson 1: Without RTD, parking in Denver is a lot like parking in New York City - scarce, cutthroat and expensive. Overnight, normally polite motorists were transformed into snotty, aggressive parking-place sneaks. And those who normally would never dream of paying $10 for a spot suddenly were bragging about finding $25 bargains outside the baseball stadium. One of the cheapest skinflints I know even took to parking long term in a metered spot and accepting the fate of a $20 ticket, figuring it was cheaper than the prices at the few spaces left downtown.

Lesson 2: Downtown businesses are doomed without mass transit. As regular bus riders took to their cars, driving downtown became a test of patience. I sat through three light changes at East Colfax Avenue and Grant Street on Monday evening. That was enough gridlock for me. I biked to work the rest of the week and otherwise avoided downtown.

Lesson 3: Denver Public Schools may be in a financial pinch now, but things would be desperate if not for RTD providing transportation for high-school students in lieu of yellow buses. The district even had to schedule makeup sessions for federally mandated tests because of high absentee rates for students who rely on RTD to get to school.

Lesson 4: Sleepless in suburbia is no way to live. The heavy traffic on the major routes through town caused an average increase in commuting times of about 30 minutes, according to those monitoring the highways from news helicopters.

Lesson 5: The anti-FasTracks crowd was wrong. Light rail rocks. When the trains stopped running, traffic went nuts, especially along the popular southwest corridor light-rail line. Those 37,000 riders who board the trains each day may be doing it for the comfort, convenience, the low cost or, as the vice president has famously suggested, a sense of personal virtue. Whatever. When they were forced back into their cars, it created havoc for both the virtuous and shameless alike.

Lesson 6: It could have been a lot worse. The RTD strike happened during a week of mostly warm, dry spring weather. To fully appreciate life without mass transportation, Denver commuters must visualize the same situation with 10 inches of snow, freeway traffic at a standstill and the bicycle option available only to the seriously hard-core. We got off easy.

Finally, the governor, a.k.a. Twelve-Lane Bill, was wrong back in 2004 when he said the impact of mass transit on traffic congestion is "imperceptible." Even if the taxpayers were willing to build the highways necessary to carry all the cars, and motorists were willing to pay for more toll roads, and even if we all could abide greater dependence on $3-a-gallon gasoline and $20-a-day parking spaces, without mass transit we'd be, um, freaked. We'd spend hours mired in gridlock, especially around entertainment and sports events. Elderly citizens would be housebound. The poor would have few options for getting to work. The air would be more toxic, the community less hospitable, the economy less vital.

Parking Cost Savings

Shifts from automobile to transit travel reduce parking costs. Reduced vehicle ownership reduces residential parking demand (including on-street parking demand in residential areas), and reduced vehicle trips reduce non-residential parking demand, such as commercial parking requirements. This benefit can manifest itself as user cost savings where parking is priced, reduced parking congestion and increased convenience to motorists, and reductions in the need for businesses and governments to subsidize parking facilities. Reduced parking demand can also provide indirect benefits by reducing the amount of land needed for parking facilities, allowing more clustered and infill development. These land use benefits are discussed in more detail in a later chapter.

Measuring Parking Cost Savings

Parking cost savings can be calculated by multiplying reduced automobile round trips times average cost per parking space. These values will vary depending on conditions. Parking tends to be expensive and in limited supply under urban-peak conditions where shifts from driving to transit are most common, so transit tends to provide significant parking cost savings. In suburban and rural areas, parking may be inexpensive and abundant so there is less short-term benefit. Where parking is priced, parking cost savings go to users rather than businesses. Cambridge Systematics (1998) provides detailed instructions for calculating parking cost savings.

Table 17 illustrates typical parking facility costs. Park & ride trip savings consist of the difference in parking costs between a park & ride lot and worksites. Transit vehicle parking costs are incorporated into operational expenses. Transit may increase parking costs where bus stops displace on-street parking spaces.

Table 17 **Typical Parking Facility Costs** ("Parking Evaluation," VTPI, 2003)

Type of Facility	Land Costs	Land Costs	Construction Costs	O & M Costs	Total Cost	Daily Cost
	Per Acre	*Per Space*	*Per Space*	*Annual, Per Space*	*Annual, Per Space*	*Daily, Per Space*
Suburban, On-Street	$0	$200	$2,000	$200	$408	$1.36
Suburban, Surface, Free Land	$50,000	$0	$2,000	$200	$389	$1.62
Suburban, Surface	$50,000	$455	$2,000	$200	$432	$1.80
Suburban, 2-Level Structure	$50,000	$227	$10,000	$300	$1,265	$5.27
Urban, On-Street	$250,000	$1,000	$3,000	$200	$578	$1.93
Urban, Surface	$250,000	$2,083	$3,000	$300	$780	$3.25
Urban, 3-Level Structure	$250,000	$694	$12,000	$400	$1,598	$6.66
Urban, Underground	$250,000	$0	$20,000	$400	$2,288	$9.53
CBD, On-Street	$2,000,000	$8,000	$3,000	$300	$1,338	$4.46
CBD, Surface	$2,000,000	$15,385	$3,000	$300	$2,035	$6.78
CBD, 4-Level Structure	$2,000,000	$3,846	$15,000	$400	$2,179	$7.26
CBD, Underground	$2,000,000	$0	$25,000	$500	$2,645	$8.82

This table illustrates the costs of providing a parking space under various conditions. Cost recovery prices must be even higher to account for profits and load factors, if not every space is rented every day. (CBD = Central Business District.)

If an area has abundant parking supply, reduced driving may provide little short term parking cost savings, since the spaces will simply be unoccupied. But over time reduced parking demand usually provides economic benefits, by avoiding the need to increase supply or allowing facilities to be leased, sold or converted to other uses. It can also provide environmental and aesthetic benefits by reducing the amount of land paved for parking facilities. Cambridge Systematics (1998) and Litman (2003) provide guidance for calculating parking cost savings under various conditions.

Table 18 indicates recommended values for calculating parking cost savings that result when automobile travel shifts to public transit. Park & Ride trip savings consist of the difference in parking costs between Park & Ride and worksite parking facilities. These costs are measured per round-trip, rather than per vehicle-mile as with most other costs. These can be converted to per-mile units by dividing by average round trip lengths, which is currently about 7 miles, but may be higher for some transit trips, such as commuter express services.

Table 18 **Typical Parking Cost Values** (Per Round-Trip)

	Small City	Medium City	Large City
Commute Trips	$3.00	$6.00	$9.00
Other Trips	$2.00	$4.00	$6.00
Average	*$2.50*	*$5.00*	*$7.50*

This table reflects estimated average avoided parking costs for a trip shifted from driving to public transit, depending on the destination and trip type.

Dividing these values in half to reflect individual trips, and assuming that most peak-period trips are to urban destination, and off-peak trips tend to be to more suburban destination, default values are $2.18 per peak trip and $0.84 per off-peak trip. The higher cost of peak-period trips also reflects the fact that they tend to be commute trips, in which a car would be parked all day, while more off-peak trips are for errands with shorter parking requirements.

Safety, Health and Security Impacts

Transit use can affect safety, health and security in several ways.

Traffic Safety

Transit is a relatively safe travel mode, as indicated in Table 19. Transit passengers have about one-tenth the fatality rate as car occupants, and even considering risks to other road users transit causes less than half the total deaths per passenger-mile as automobile travel. Since risks to other road users is hardly affected by increased occupancy, average crash costs tend to decline with increased vehicle occupancy.

Table 19 **U.S. Transport Fatalities, 2001** (BTS, Tables 2-1 and 2-4; APTA; TRB, 2002)

	Fatalities			Veh. Travel	Occupants	Pass. Travel	Fatalities Rate	
	User	Others	Totals	Bil. Miles		Bil. Miles	Users	Others
Passenger Car	20,320	3,279	23,599	1,628	1.59	2,589	7.9	1.3
Motorcycle	3,197	19	3,216	9.6	1.1	10.6	303	1.8
Trucks – Light	11,723	3,368	15,091	943	1.52	1,433	8.2	2.3
Trucks – Heavy	708	4,189	4,897	209	1.2	251	2.8	16.7
Intercity Bus	45		45	7.1	20	142	0.3	-
Commercial Air						-	0.3	
Transit Bus	11	85	96	1.8	10.8	19	0.6	4.4
Heavy Rail	25	6	31	0.591	24	14	1.8	0.4
Commuter Rail	1	77	78	0.253	37.7	9.5	0.1	8.1
Light Rail	1	21	22	0.053	26.8	1.4	0.7	14.8
Pedestrians	4,901	0	4,901	24.7	1	25	198	-
Cyclists	732	0	732	8.9	1	8.9	82.2	-

Table 20 compares crash fatality rates for various types of transit.

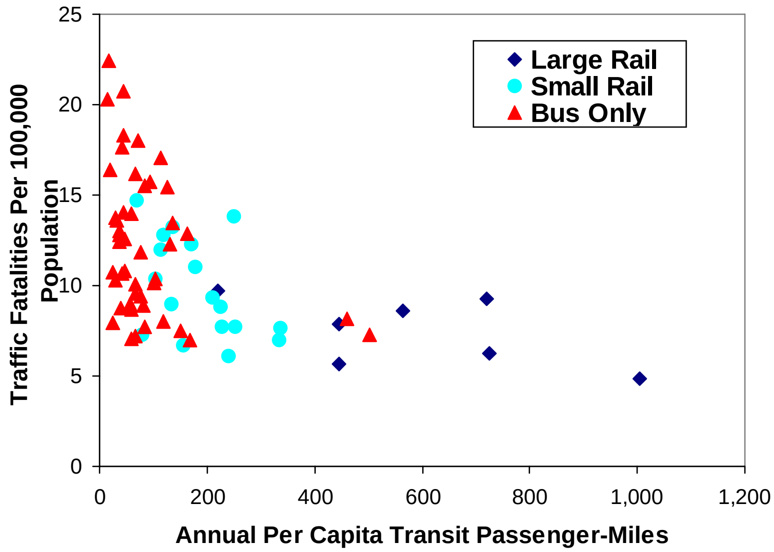
Table 20 **U.S. Transit Fatalities, 1999** (APTA, 2001)

	Bus	Commuter Rail	Demand Response	Heavy Rail	Light Rail	Trolley Bus	Total
Fatalities (Excludes Suicides)							
Patrons	13	2	5	22	2	0	44
Employees	5	3	8	1	3	0	20
Other	86	68	3	3	8	1	169
Totals	*104*	*73*	*16*	*26*	*13*	*1*	*233*
Fatality Rate Per Billion Passenger Miles							
Patrons	0.61	0.23	6.15	1.71	1.66	0.00	0.98
Employees	0.24	0.34	9.84	0.08	2.49	0.00	0.44
Other	4.06	7.76	3.69	0.23	6.63	5.38	3.75
Totals	*4.90*	*8.33*	*19.68*	*2.02*	*10.78*	*5.38*	*5.17*

This table shows crash fatalities and fatality rates for various types of transit in the U.S.

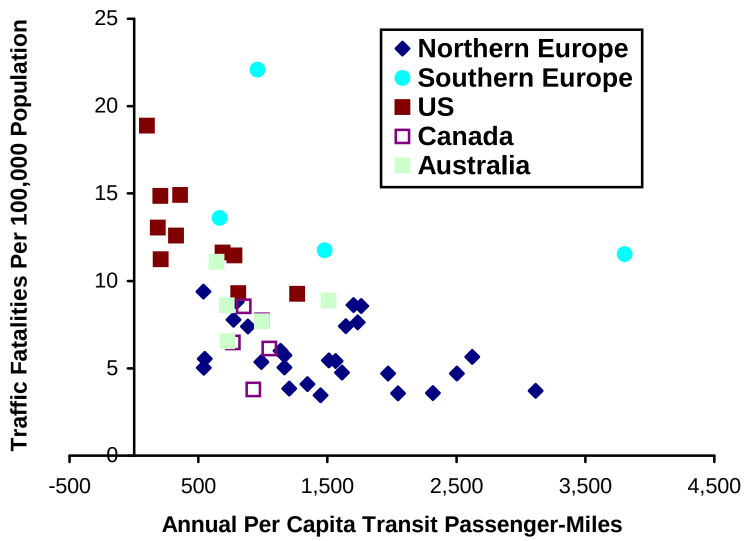
Figures 7 and 8 show U.S. and international data indicating declining per capita traffic fatalities with increased transit ridership. For additional discussion of transit safety impacts see Litman (2004b) and Steer Davies Gleave (2005).

Figure 7 **Traffic Deaths** (Litman, 2004a)



Per capita traffic fatalities tend to decline with increased transit ridership. Since cities with rail have higher average transit ridership, they tend to have fewer traffic fatalities. These values include deaths to transit passengers, automobile passengers, and pedestrians.

Figure 8 **International Traffic Deaths** (Kenworthy and Laube, 2000)



International data indicate that crash rates decline with increased transit ridership.

To the degree that transit provides a catalyst for more accessible land use it tends to further increase road safety. Residents of transit-oriented communities with high ridership rates have significantly lower per capita traffic fatality rates than residents of more automobile-dependent, sprawled communities, as indicated in the figures below (Newman and Kenworthy, 1999; "Land Use Evaluation," VTPI, 2003; Litman, 2004a).

Health Impacts

Inadequate physical activity contributes to cardiovascular disease, diabetes, hypertension, obesity, osteoporosis and some cancers. Many health experts believe that increased active transportation (walking and cycling) is one of the most practical ways to increase community Health and Fitness (AJHP, 2003). Most transit trips involve walking or cycling links, so transit use tends to increase physical activity (Weinstein and Schimek, 2005; Besser and Dannenberg, 2005). Travel surveys indicate that the average walking distance involved in a transit trip is five to ten times longer than the average walking distance of an automobile trip. Efforts to encourage transit, reduce driving, and create transit oriented development often improve pedestrian and cycling conditions, which can further increase fitness and health.

Personal Security

Personal Security refers to freedom from assault, theft and vandalism. Transit travel is sometimes thought to impose security risks on passengers and transit station neighbors, but these do not necessarily represent increased risk, since motorists also encounter threats from car thefts, road rage, and aggressive driving (STPP, 1999). Overall, transit tends to be safer than automobile travel (Litman, 2005a).

These risks can be reduced by programs to Address Security Concerns. Transit improvements and TDM strategies that encourage transit use tend to increase rider security, because busy pedestrian facilities and transit waiting areas tend to be self-patrolling (fellow transit riders discourage and report crimes), and increased ridership can justify more safety programs. Although an individual may perceive that transit travel reduces personal security, increased transit use by responsible people tends to reduce overall risks to the community (Morino Garcia, 2005).

Measuring Safety, Health and Security Impacts

Accident costs and health risks are often monetized for public policy analysis (Litman, 2003). Although an individual's life has essentially infinite value (most people would not give up their life for any size monetary payment), many private and public decisions involve tradeoffs between risk and financial costs. For example, when consumers decide whether to pay extra for safety options such as air bags, and when communities allocate funds for services such as law enforcement, fire protection, and medical services, they are essentially placing a price on marginal changes in human safety and health.

Traffic safety benefits are usually estimated at $2 to $5 million per fatality avoided, and smaller values for non-fatal crashes (Blincoe, 1994). These values indicate that crash costs average 5-15¢ per automobile vehicle-mile (Miller, 1991). This analysis uses 10¢ per vehicle mile as an average, of which 6¢ is internal (borne directly by vehicle occupants) and 4¢ is external (imposed on others). Since automobiles average 1.5 occupants, internal crash costs average 4¢ per passenger-mile.

Bus transit is estimated to impose external crash costs of 25.8¢ per vehicle-mile, based on 10¢ per mile automobile crash costs increased by the crash fatality ratio (39.6/13.4), of which 86% are to other road users. Risks to bus occupants are estimated at 0.5¢ per passenger-mile. Bus crash costs therefore average 28.9¢ per bus-mile, including risks to

5.2 average passengers and one driver, plus risks imposed on other road users. External risks do not increase with vehicle occupancy so unit costs decline as load factors increase. A bus with 10 passengers has total estimated crash costs of 31.3¢ per vehicle mile (25.8¢ + [0.5¢ x 10 passengers and a driver]), but doubling passengers only increases cost 16% to 36.3¢. A bus that replaces 10 automobile trips provides 68.7¢ per mile net safety benefits. Rail transit tends to impose even lower risks on passengers, and somewhat higher risks on non-occupants, although there is virtually no incremental risk from increased occupants in existing rail vehicles.

Transit provides greater safety benefits if it leverages additional traffic reductions, as described in the "Traffic Impacts" chapter of this guide. If each passenger-mile of transit travel reduces two to four vehicle-miles of travel, as some estimates indicate, each transit passenger-mile provides an additional 20-40¢ in crash cost savings.

Public health benefits from increased walking and cycling caused by transit use are difficult to measure and depend on the type of transit program implemented (Frank and Engelke, 2000; AJHP, 2003). To the degree that transit causes otherwise sedentary people to walk or bicycle an hour or more a week it provides significant health benefits. Because inadequate physical activity is such a large health risk, the public health benefits of increased transit use and more transit-oriented development may be comparable to transit's traffic safety benefits, although more research is needed to verify this.

Personal security impacts are difficult to quantify and vary depending on conditions. The common perception that transit travel is unsafe is a problem that transit planners must address, but there is little evidence that shifting from driving to transit actually increases total assaults or thefts in a community, taking into account risks to motorists such as road rage, vehicle thefts and vandalism. In many situations, transit service improvements include efforts to increase security for both transit riders and non-users. For example, improved street lighting at transit stops and downtown security patrols implemented as part of transit oriented development can reduce a variety of risks.

Many people have an exaggerated sense of transit risks. Transit accidents and assaults tend to receive excessive media attention. For example, in one 8 month period newspapers published 40 stories with headlines linking "transit" and "death," but only 14 linking "auto" or "car" with death, despite the much greater number of fatalities caused by automobile accidents (McKay and Smith Lea, 1996). Other studies find that city residents are less likely to die a violent death than suburban residents, due to the higher automobile fatality rates in automobile dependent areas (Durning, 1996; Lucy, 2002).

Roadway Costs

Roadway costs include road maintenance, construction and land, and various traffic services such as planning, policing, emergency services and lighting. These costs are affected by vehicle weight, size and speed. Heavier vehicles impose more road wear, and larger and faster vehicles require more road space. These costs are not necessarily marginal. For example, a 10% reduction in vehicle traffic does not necessarily cause a 10% reduction in roadway costs. In urban areas with significant congestion problems and high land values, even a modest reduction in traffic volumes can provide large savings.

Transportation economists have performed numerous studies (called *cost allocation* or *cost responsibility* studies) that investigate the share of roadway costs imposed by various types of vehicles (FHWA, 1997; "Roadway Costs," Litman, 2003). Most of these studies only consider current direct roadway construction and maintenance expenditures, and sometimes highway patrol services. Public costs not reflected in transport agency budgets are generally ignored, such as the opportunity costs of roadway land, traffic planning, local policing, emergency services, snow plowing and street lighting.

Where a transit project avoids or defers the need for major highway capacity expansion, the avoided costs can be considered a benefit of transit. Urban highway capacity expansion typically costs $4-10 million per lane-mile for land acquisition, lane pavement and intersection reconstruction (Cambridge Systematics, 1992). This represents an annualized cost of $200,000-500,000 per lane-mile (assuming a 7% interest rate over 20 years). Dividing this by 4,000 to 8,000 additional peak-period vehicles for 250 annual commute days indicates a cost of 10-50¢ per additional peak-period vehicle-mile.

Measuring Roadway Costs and Benefits

Table 21 summarizes roadway costs and revenues for various vehicle types. This indicates that, considering only direct roadway expenditures, automobile use costs average 3.5¢ per mile and pays 2.6¢ per mile in fuel taxes, resulting in net costs averaging 0.9¢ (1.1¢ in 2003 dollars), while buses cost 11.8¢ per mile and pay 4.6¢ in taxes, resulting in 7.2¢ per mile net costs (8.9¢ in 2003 dollars). Bus road wear costs are reduced if roadways are built for heavy vehicles, which is common on major roads to accommodate freight and service trucks. Roadway costs approximately double if the value of right-of-way land is also considered. Traffic service costs average 1-4¢ per automobile-mile.

Table 21 **Roadway Cost Responsibility Per Mile** (FHWA, 1997)

Vehicle Class	Federal Costs	State Costs	Local Costs	Total Costs	User Payments	Net Costs
Automobiles	$0.007	$0.020	$0.009	$0.035	$0.026	$0.009
Pickups and Vans	$0.007	$0.020	$0.009	$0.037	$0.034	$0.003
Single Unit Trucks	$0.038	$0.067	$0.041	$0.146	$0.112	$0.034
Combination Trucks	$0.071	$0.095	$0.035	$0.202	$0.157	$0.044
Buses	$0.030	$0.052	$0.036	$0.118	$0.046	$0.072
All Vehicles	*$0.011*	*$0.025*	*$0.011*	*$0.047*	*$0.036*	*$0.010*

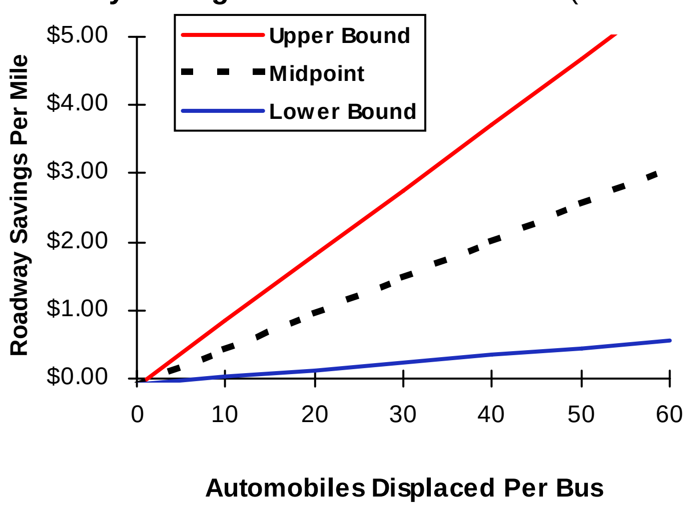
This table shows estimated costs and user payments for various vehicles. (1994 U.S. dollars).

Table 22 **Roadway Cost Impacts of Automobile To Transit Shifts**

Category	Description	Cost Impact
Road wear	Costs of road deterioration due to vehicle traffic, road repair costs, and increased strength during road construction to minimize deterioration.	Buses tend to increase these costs due to heavy axle weights.
Lane size	Incremental costs of wider lanes required to accommodate larger vehicles. Generally set to accommodate trucks and service vehicles.	Bus service may increase lane requirements in some locations.
Traffic services	Roadway planning, traffic controls, policing, lighting, etc.	Because these costs are based on traffic volumes, they tend to decline.
Traffic capacity	Costs of adding traffic lanes, improving intersections and other measures to accommodate increased traffic volumes and reduce traffic congestion.	Can significantly reduce these costs. This impact is reflected on congestion costs values.

Table 22 summarizes cost impacts of automobile to transit shifts. Where vans and small buses replace driving on local street, roadway cost savings typically average 1-3¢ per reduced automobile-mile. Where full-size buses operate on local streets, there is probably little or no roadway cost savings. Where buses operate on major roadways designed to accommodate heavy vehicles, roadway costs are reduced as indicated in Figure 9. Where urban automobile travel shift to rail transit, savings typically average about 5¢ per vehicle-mile reduced, or 2¢ per mile net costs taking into account fuel tax revenues). If a transit service or improvement avoids or defers the need for a specific highway project, avoided costs can be calculated. Such savings typically average 15-50¢ per reduced urban-peak automobile-mile.

Figure 9 **Roadway Savings Per Mile of Bus Travel** (2001 U.S. dollars)



This graph illustrates roadway cost savings for a shift from automobile to bus travel. Thirty car drivers shifting to transit provides savings worth between $0.24 and $2.76 per mile, depending on assumptions. Costs based on FHWA (1997) updated to 2001 dollars, plus estimates of roadway land costs and traffic services described in Litman, 2003.

Energy Conservation and Emission Reductions

Transit can provide energy conservation and emission reduction benefits (TCRP, 2003; Potter, 2003; TRB, 2004). Shapiro, Hassett and Arnold (2002) estimate that urban transit travel consumes about half the energy and produces only 5% as much CO, 8% VOCs and about 50% the CO^2 and NOx emissions per passenger-mile as an average automobile. Newman and Kenworthy (1999) find that increased regional transit use is associated with lower per capita transportation energy use. Transit energy conservation and emission reduction benefits depend on transport impacts, travel conditions, and the type of transit vehicles used.

- Strategies that increase diesel bus mileage on routes with low load factors (such as suburban and off-peak routes) may increase total energy consumption and emissions.
- Strategies that shift travel from automobile to transit using existing transit capacity (with minimal increase in transit vehicle-miles) reduce energy consumption and emissions.
- Strategies that improve fuel consumption or reduce emission rates of transit vehicles (for example, retrofitting older diesel buses with cleaner engines or alternative fuels) can provide energy conservation and emission reduction benefits.
- Strategies that reduce the total amount of congested driving (by either reducing vehicle mileage or the amount of congestion) tend to provide particularly large energy conservation and emission reduction benefits.
- Strategies that create more accessible land use patterns, and so reduce per capita vehicle mileage, can provide large energy conservation and emission reduction benefits.

Energy Conservation

Table 23 indicates average energy consumption for various travel modes. Under current conditions, U.S. transit vehicles consume about the same energy per passenger-mile as cars, although less than vans, light trucks and SUVs. This reflects low current transit load factors. Increasing ridership on existing transit vehicles consumes little additional energy. A bus with seven passengers is about twice as energy efficient as an average automobile, and a bus with 50 passengers is about ten times as energy efficient. Rail transit systems tend to be about three times as energy efficient as diesel bus transit. New hybrid buses are about twice as energy efficient as current direct drive diesel (General Motors Corp.)

Table 23 **Average Fuel Consumption 2001** (BTS, Tables 1-29, 4-20, 4-23, 4-24; APTA, 2002)

Vehicle Class	Average MPG	Mode	BTU/Pass. Mile
Passenger Cars	22.1	Car	3,578
Vans, Pickup Trucks, SUVs	17.6	Vans, Pickup Trucks, SUVs	4,495
Motorcycle	50	Aviation	4,000
Single Unit Truck	7.4	Transit, Bus	3,697
Combination Truck	5.3	Transit, Electric Light Rail	1,152
Buses	6.9	Intercity Rail, diesel	2,134
Hybrid Electric Bus (estimate)	14.0	Hybrid Electric Bus (estimate)	1,070

This table summarizes average fuel consumption per vehicle, and energy consumption per passenger-mile for various vehicle types.

Air Emission Impacts

Quantifying emission impacts of a shift from automobile to transit is challenging because there are several different types of pollutants, and many possible permutations of vehicles, engines and driving conditions. As with energy consumption, current average transit emissions are relatively high in the U.S. due to low occupancy rates, but additional riders contribute minimal additional emissions so strategies that increase ridership with less than proportional increases in vehicle mileage can provide benefits.

Older diesel engines have relatively high emission rates, but these are declining due to improved emission controls. Between 1987 and 2004, allowable emission rates have been reduced about 80%. Many transit vehicles are being converted to cleaner fuels (CNG, LPG or alcohol). Hybrid electric bus drive systems are claimed to reduce particulate and hydrocarbon emissions 90% and NOx 50% compared with conventional diesels (GM, 2003). Electric vehicles produce minimal emissions.

Table 24 **Average Emissions 1999, Grams Per Mile** (APTA, 2002)

Vehicle Type	Carbon Dioxide	CO	Nitrogen Oxides	VOCs
Bus (10 passengers)	2,387 (239)	11.6 (1.2)	11.9 (1.2)	2.3 (0.23)
Diesel Rail (20 passengers)	9,771 (489)	47.6 (2.4)	48.8 (2.4)	9.2 (0.5)
Automobile (1.5 passengers)	416 (277)	19.4 (12.9)	1.4 (1.0)	1.9 (1.3)
SUVs & Light Trucks (1.5 pass.)	522 (348)	25.3 (16.9)	1.8 (1.2)	2.5 (1.7)
Hybrid Electric Bus (10 pass.)	1,194 (119)	NA	6.0 (0.6)	0.23 (0.02)

This table summarizes average emissions of various vehicles. Numbers in parenthesis indicate emissions per passenger-mile based on indicated occupancy rates.

Noise Impacts

Traffic noise is a moderate to large cost in urban areas ("Noise Costs," Litman, 2003). Conventional buses are noisy due to their relatively large engines and low power to weight ratio. A typical diesel bus produces the noise equivalent of 5 to 15 average automobiles, depending on conditions (Delucchi and Hsu, 1998). Staiano (2001) concluded that light rail is somewhat quieter than a diesel bus, and electric trolley buses are significantly quieter. Hybrid buses are much quieter than direct drive diesel.

If a bus displaces just one unusually noisy vehicle (for example, a bus rider would have ridden a noisy motorcycle or driven a car with a faulty muffler or high volume stereo), it can reduce noise overall. If residents walk rather than drive to transit stops, local street noise is reduced. This suggests that diesel bus noise costs per trip are probably about the same as for automobile travel, and hybrid and electric transit reduces overall noise costs.

Water Pollution

Motor vehicles contribute to water pollution due to leaks from engines and brake systems, during fuel distribution, and waste fluids (such as used crankcase oil) that are disposed of inappropriately. Transit travel tends to produce less water pollution because it requires fewer vehicles, and they tend to be maintained better than private vehicles.

Measuring Energy Conservation and Emission Reduction Benefits
Computer models can predict the impacts of transport energy conservation and emission reduction strategies (Sierra Research, 2000; Transportation Air Quality Center at www.epa.gov/otaq/transp/traqmodl.htm; the *TravelMatters website at* www.travelmatters.org). Various studies monetize emission costs, and therefore the value of transport emission reductions, as described in Litman, 2003. These indicate that under typical urban conditions emission costs average 2-5¢ per vehicle-mile for a gasoline automobile, twice that for an SUV, van or light truck, and 10-30¢ per vehicle-mile for older diesel buses, with lower costs for buses with newer engines or alternative fuels. Table 25 summarizes estimated cost for various vehicles.

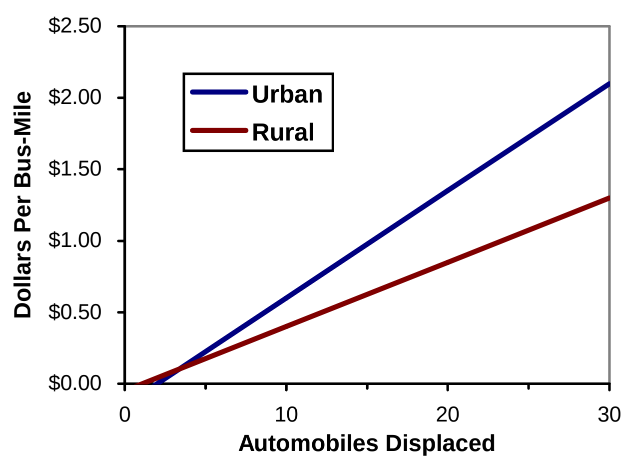
Table 25 Recommended Pollution Costs (Cents Per Vehicle-Mile)

	Urban	Suburban	*Average*
Current Diesel Bus	30¢	15¢	*22.5¢*
New Diesel Bus (meets 2004 standards)	15¢	5¢	*10¢*
Hybrid Electric Bus	5¢	3¢	*4¢*
Average Car	5¢	3¢	*4¢*
SUV, Light Truck, Van	10¢	6¢	*8¢*
Average Automobile	7.5¢	4.5¢	*6¢*

This table indicates estimated average energy, air, noise and water pollution costs of various vehicles. "Average automobile" reflects a weighted average of cars, SUVs, light trucks and vans.

Since most new transit service will be provided by newer, cleaner buses, pollution reduction benefits can generally be calculated based on a shift from average automobile to new diesel or hybrid electric buses. Figure 10 illustrates the estimated benefits of shifts from driving to new diesel buses. Benefits are larger for CNG, hybrid or electric power transit vehicles. As with other impacts, greater benefits result if transit improvements leverage an overall reduction in per-capita automobile mileage.

Figure 10 Pollution Reduction Benefits of Automobile To New Bus Shifts



This illustrates estimated pollution-reduction benefits caused by a shift from average automobiles to new diesel transit buses. For example, if a suburban bus carries 20 passengers, half of whom would have driven an automobile, the net pollution-reduction benefit is estimated to be 40¢ per bus-mile ([4.5¢ x 10] – 5¢).

Travel Time Impacts

Special consideration is needed when evaluating transit travel time costs. Where roads are congested and transit has separate right-of-way or other transit priority features, transit travel may be faster than driving. On the other hand, in many situations, transit travel takes more time than the same trip made by automobile, particularly when walking and waiting time are considered.

Various studies indicate that consumers place a higher cost on time spent driving, particularly in congestion, than the same amount of time spent as a passenger in pleasant conditions (i.e., uncrowded, a comfortable seat, clean and safe vehicles, not too noisy), because passengers experience less stress and can rest, read or even work. According to current travel time cost values, passengers' travel time is charged at 35% average wage rates, while drivers' time is charged at 50% of wage rates, with a premium of 33% for Level of Service (LOS) D, 67% for LOS E, and 100% for LOS F (ECONorthwest and PBQD, 2002; "Travel Time," Litman, 2003). Although different agencies assign different values to driver and passenger time, there is little disagreement among experts over the basic concept that, for an average consumer, time spent driving in congestion incurs a higher cost than the same amount of time spent as a comfortable passenger.

Of course, each trip is unique. For some trips transit is not an option, because it does not serve a destination, or travelers carry large loads, or to have a vehicle available at work. Some travelers do not want to take transit because they smoke, or have difficulty with the walking links of a transit trip. Some people dislike riding transit or enjoy driving, even in congested conditions. But if quality transit is available, travelers will self-select driving or transit based on their needs and preferences. This maximizes consumer surplus by letting consumers choose the best option for each trip.

Various studies show that driving in congestion and uncomfortable transit travel causes psychological stress. Wener, Evans and Boately, (2005) surveyed transit commuters before and after a major public transit service improvement that provided a "one-seat ride" from New Jersey into New York City who previously had to transfer trains. Respondents indicated reduced stress in the post-change period, including reduced stress at their jobs, while those staying with the previous service did not. Women who had children at home appear to experience the greatest stress reduction.

A survey of U.K. rail passengers found that many use their travel time productively for activities such as working or studying (30% some of the time and 13% most of the time), reading (54% some of the time and 34% most of the time), resting (16% some of the time and 4% most of the time) and talking to other passengers (15% some of the time and 5% most of the time), and so tend to place a positive utility on such time (Lyons, Jain and Holley, 2007). When asked to rate their travel time, 23% indicated that "I made very worthwhile use of my time on this train today", 55% indicated that "I made some use of my time on this train today," and 18% indicated that "My time spent on this train today is wasted time." The potion of travel time devoted to productive activity is higher for business travel, and tends to increase with journey duration.

These factors have important implications for evaluating public transit improvements. Strategies that increase transit speeds and reliability provide direct benefits to users, particularly if they provide an alternative to driving in congested conditions. Strategies that increase transit user comfort, security and prestige can reduce travel time costs even if they don't reduce the amount of time actually spent in travel, because they reduce per-minute costs. Strategies that improve access to transit, for example by making it easier to walk or cycle to transit stops, also reduce travel time costs. Travelers who shift from driving to transit in response to transit improvements or other positive incentives (such as financial benefits to transit users) can benefit overall, even if transit trips take more time.

Measuring Travel Time Costs and Benefits

The value of travel time changes can be calculated using a comprehensive travel time cost framework that takes into account the factors described above, such as indicated in the table and box below. Travel time should be measured door-to-door, taking into account each trip link, including time spent walking and waiting. Conventional transportation models are generally not very sensitive to qualitative factors, and therefore tend to undervalue transit improvements that improve rider comfort, convenience and access speed. Below are some guidelines for quantifying travel time.

- Personal travel is usually estimated at one-quarter to one-half of prevailing wage rates.
- Travel time costs for drivers tend to increase with congestion, and for passengers if vehicles are crowded or uncomfortable. Unexpected delays impose high costs.
- Costs tend to be lower for shorter trips and small travel time savings, and tend to increase for longer commutes (more than about 20 minutes).
- Under pleasant conditions, walking and cycling can have positive value, but under unpleasant or unsafe conditions, time spent walking, cycling and waiting for transit has costs two or three times higher than time spent traveling.
- Travel time costs tend to increase with income, and tend to be lower for children and people who are retired or unemployed (put differently, people with full-time jobs are generally willing to pay more for travel time savings).
- Personal preferences vary. Some people prefer driving while others prefer transit or walking, as reflected in their travel time cost values.

Table 26 **Recommended Value of Travel Time** (ECONorthwest & PBQD, 2002)

Time Component	Reference	Value
In-Vehicle Personal (local)	Of wages	50%
In-Vehicle Personal (Intercity)	Of wages	70%
In-Vehicle Business	Of total compensation	100%
Excess (waiting, walking, or transfer time) Personal	Of wages	100%
Excess (waiting, walking, or transfer time) Business	Of total compensation	100%

This table illustrates USDOT recommended travel time values. Personal travel is calculated relative to wages, and business travel relative to total compensation, averaging 120% of wages.

Box 1 **Recommended Travel Time Values** ("Travel Time Costs," Litman, 2003)

	Travel Time Values
Commercial vehicle driver	Wage rate plus fringe benefits
Personal vehicle driver	50% of current average wage
Adult car or bus passenger	35% of current average wage
Child passenger under 16 years	25% of current average wage

Congestion increases driver's travel time costs by the following amounts according to roadway Level of Service (LOS) ratings:

LOS D: multiply by 1.33 LOS E: multiply by 1.67 LOS F: multiply by 2.0

Under unpleasant or insecure conditions (waiting for transit in a dirty and insecure area, or walking on busy roads that lack sidewalks), time spent walking, cycling and using transit has two or three times the cost of time spent traveling, depending on the degree of discomfort.

This box summarizes travel time values developed by leading transportation economists.

For this analysis we recommend a default value of $8.00 per hour for travelers in comfortable conditions and $16 per hour for travelers in uncomfortable conditions, including walking to and waiting at transit stops, and riding crowded transit buses.

Land Use Impacts

Transit can help achieve various land use planning objectives by reducing the amount of land that must be paved for roads and parking facilities in an area, and providing a catalyst for more compact urban redevelopment (Litman, 1995; Cambridge Systematics, 1998). Transit is an important component of *smart growth*, which refers to policies designed to create more resource efficient and accessible land use patterns. Table 27 lists potential smart growth benefits.

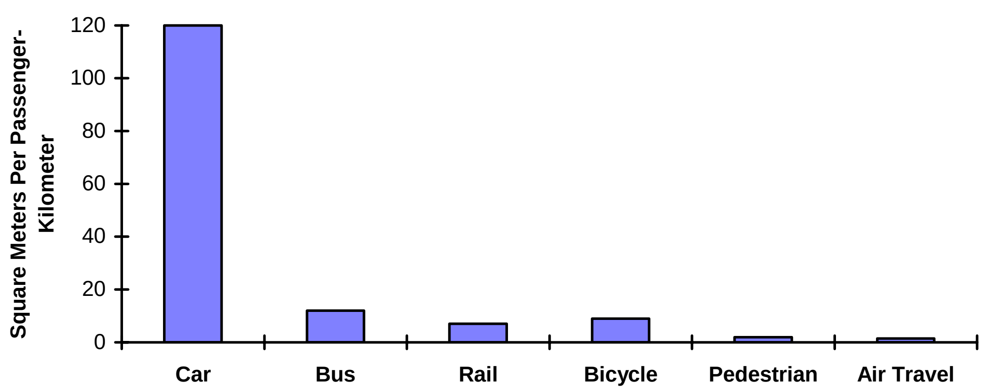
Table 27 **Smart Growth Benefits** (Burchell, et al, 1998; Litman, 1995)

Economic	Social	Environmental
Reduced development and public service costs. Consumer transportation cost savings. Economies of agglomeration. More efficient transportation.	Improved transportation choice, particularly for nondrivers. Improved housing choices. Community cohesion.	Greenspace and wildlife habitat preservation. Reduced air pollution. Reduce resource consumption. Reduced water pollution. Reduced "heat island" effect.

This table summarizes various benefits to society of smart growth development patterns.

Transit can reduce the amount of land required for roads and parking facilities compared with urban-peak automobile trips, as illustrated in Figure 11. Transit is particularly helpful in creating certain land use patterns including major commercial centers (more than 5,000 employees in one area), multi-modal (walkable) neighborhoods, urban redevelopment, and some types of tourist attractions.

Figure 11 **Road Space By Mode** (Banister and Button, 1993)



Transit requires far less space than automobile travel.

Transit-oriented development can provide economic benefits by improving accessibility, reducing transport costs, and providing economies of agglomeration, as described in the next section of this guide. In some cases, increased property values near transit stations can offset most or all transit subsidy costs (RICS, 2002; Smith and Gihring, 2003). Even people who do not use transit can benefit from these land use patterns.

Not every transit project has these effects. Appropriate land use policies, transit ridership incentives and consumer acceptance are necessary to be effective. The following types of transit improvements tend to have the greatest positive land use impacts:

- Transit programs that are part of an overall smart growth land use program.
- Transit oriented development, which intentionally integrates transit improvements with compatible land use development.
- Transit improvements that encourage infill and redevelopment of older urban neighborhoods.
- Transit stations located at major commercial centers with large numbers of commuters.
- Transit improvements as an alternative to roadway capacity expansion.
- New urbanism, parking management and other TDM policies implemented in conjunction with transit improvements.

Transit can also have some negative land use impacts. Rail facilities require land, can divide neighborhoods, and can be unattractive. In some situations transit improvements can increase urban sprawl by facilitating longer-distance commutes.

Measuring Land Use Impacts

The first step in valuing these impacts is to determine how a particular transit program or policy will affect land use patterns, including changes in the amount of land used for transport facilities (roads, parking, rail lines and terminals), changes to development patterns (density, clustering, urban expansion, per capita pavement, etc.), changes in accessibility (the ease of travel between destinations), emergency service response times, and changes in per capita vehicle ownership and VMT. Some communities have comprehensive transportation/land use models that can predict these impacts, but in most cases predictions rely on professional judgment by planners and real estate professionals.

The final step is to place of monetary value on impacts as much as possible. Some impacts are monetary, such as reduced costs of providing public services to more clustered development, and parking cost savings that result from reduced vehicle ownership. Others require placing a value on non-market goods. For example, monetized values may be assigned to greenspace preservation. Impacts that cannot be monetized should be described qualitatively. For example, equity impacts can be quantified using indicators of the change in accessibility by disadvantaged groups (e.g., the ability of people with disabilities or low incomes to access common destinations).

Generally, impacts should be measured per capita. Increased density can increase the intensity of some impacts within a particular area, but reduces costs per capita. For example, higher development densities may reduce greenspace (parks, lawns and farms) within a neighborhood, but preserve regional greenspace by reducing per capita pavement and urban expansion. Similarly, increased development density tends to increase per-acre vehicle trips and pollution emissions, but reduce per capita impacts, since residents of more clustered communities tend to drive fewer annual vehicle-miles.

A more qualitative approach is to identify a community's land use development goals and objectives (based on community plans and other official documents), and rate each transportation option in terms of effects on them. For example, many communities have goals to encourage infill development, create more multi-modal communities, protect and redevelop existing neighborhoods, improve walking conditions, and preserve greenspace. Transit improvements can help achieve these objectives, particularly if implemented as part of an integrated community development program.

A matrix such as the one below can be used to evaluate and compare the land use impacts of various transport options based on a particular community's planning objectives. The simplest approach is to check a box if an option supports an objective. A better approach is to rate each objective, for example from 5 (very supportive) to –5 (very harmful). Objectives can be weighted to reflect their relative importance. For more information see discussion of *Multi-Criteria Analysis* in Litman, 2001b.

Land Use Impact Matrix

Planning Objective	Option 1	Option 2	Option 3
1. Reduces roadway and parking facility land requirements.			
2. Reduces total impervious surface coverage (amount of land covered by roads, parking and buildings).			
3. Encourages urban infill and redevelopment of existing neighborhoods.			
4. Increases development densities (residents and jobs per acre).			
5. Increases accessibility (the ease of travel between common destinations), particularly for non-drivers.			
6. Improves community walkability (quality of walking conditions).			
7. Reduces per-capita vehicle travel.			
8. Improves quality or reduces costs of public service (emergency response, garbage collection, utility networks and services, schools, recreation facilities, etc.)			
9. Improves housing options (types of housing available) and affordability (by reducing parking costs and land requirements).			
10. Enhances neighborhood livability (environmental quality experienced by people who live, work and visit an area).			
11. Preserves greenspace (parks, farms, forests, etc.).			
12. Preserves cultural resources (historic sites and traditional communities).			
13. Enhances community cohesion (quantity and quality of interactions between people who live and work in a community)			
14. Supports local economic development plans (e.g., downtown redevelopment, tourist industry expansion, etc.).			
15. Others…			
Totals			

A matrix such as this can be used to evaluate and compare land use impacts. It should reflect a community's planning objectives. Each option is rated to indicate how much it supports or contradicts each objective.

Economic Development Impacts

Economic development refers to increased productivity, business activity, employment, income, property values and tax revenue. Transit can provide various economic development benefits (Cambridge Systematics, 1998; Forkenbrock and Weisbrod, 2001; ECONorthwest and PBQD, 2002; Litman, 2004a).

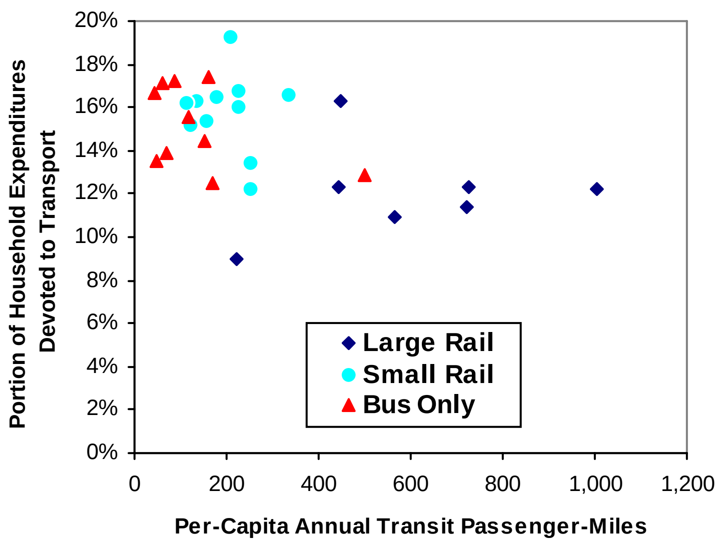
Direct Expenditures

Because transit is labor intensive, transit expenditures tend to provide more jobs and local business activity than most other transportation investments. A million dollars spent on public transit typically generates 30-60 jobs (ECONorthwest and PBQD, 2002; APTA, 2003). A typical set of transit investments creates 19% more jobs than the same amount spent on a typical set of road and bridge projects (STPP, 2004).

Consumer Expenditures

Transit supports economic development by shifting consumer expenditures. Residents of cities with quality transit systems tend to spend less on transportation overall, as illustrated below (also see Newman and Kenworthy, 1999). For example, residents of cities with large, well-established rail transit systems spend an average of $2,808 on personal vehicles and transit (12.0% of their total household expenditures), compared with $3,332 in cities that lack rail systems (14.9% of total household expenditures), despite higher incomes and longer average commute distances in rail cities.

Figure 12 **Percent Transport Expenditures** (Litman, 2004a)



The portion of total household expenditures devoted to transportation (automobiles and transit) tends to decline with increased per-capita transit ridership.

Consumer expenditures on vehicles and fuel provide relatively little employment or business activity per dollar because they are capital intensive and most of their value is imported from other areas. One study found that each 1% of travel shifted from automobile to transit in San Antonio, Texas increases regional income about $2.9 million

(5¢ per mile shifted), adding 226 regional jobs, as summarized in Table 28. Other studies find similar impacts (ASTRA, 2000).

Table 28 **$1 Million Expenditure Economic Impacts** (Miller, Robison & Lahr, 1999)

Expenditure Category	Regional Income	Regional Jobs
Automobile Expenditures	$307,000	8.4
Non-automotive Consumer Expenditures	$526,000	17.0
Transit Expenditures	$1,200,000	62.2

This table shows economic impacts of consumer expenditures in San Antonio, Texas.

Land Use Efficiencies

As described earlier, transit tends to create higher density, more accessible land use patterns, which tends to increase regional productivity (Litman, 1995; Coffey and Shearmur, 1997). One published study found that doubling a county-level density index is associated with a 6% increase in state-level productivity (Haughwout, 2000). Although these impacts are difficult to measure and may partly reflect economic transfers, there are often large net gains in productivity and economic activity.

Property Values

Property values generally increase near areas served by quality transit, particularly near rail stations (RISC, 2002; Hass-Klau, Crampton and Benjari, 2004). The table below summarizes property value increases near rail transit stations in various European and North American cities. Other studies report similar results (Smith and Gihring, 2003).

Table 29 **Rail Station Proximity Impacts on Property Values** (Hass-Klau, Cramption and Benjari, 2004)

City	Factor	Difference
Newcastle upon Tyne	House prices	+20%
Greater Manchester	Not stated	+10%
Portland	House prices	+10%
Portland Gresham	Residential rent	>5%
Strasbourg	Residential rent	+7%
Strasbourg	Office rent	+10-15%
Rouen	Rent and houses	+10%
Hannover	Residential rent	+5%
Freiburg	Residential rent	+3%
Freiburg	Office rent	+15-20%
Montpellier	Property values	Positive, no figure given
Orléans	Apartment rents	None-initially negative due to noise
Nantes	Not stated	Small increase
Nantes	Commercial property	Higher values
Saarbrűcken	Not stated	None-initially negative due to noise
Bremen	Office rents	+50% in most cases

This table summarizes how property values are affected by proximity to rail stations in various cities.

Productivity Gains

Transit services can increase economic productivity by improving access to education and employment (as discussed in the *Mobility Benefits* section), reducing traffic congestion, roads and parking facility costs, accidents and pollution (as discussed in the *Efficiency Benefits* section), by increasing land use efficiencies (as discussed in the *Land Use* section), and by supporting certain industries, such as tourism. For example, transit services may benefit a restaurant by increasing the pool of available employees and reducing absenteeism from vehicle failures, reducing employee parking costs, and by providing mobility for some tourists. Similarly, a delivery company may be more productive if transit reduces traffic congestion. Aschauer and Campbell (1991) found that transit investments provide more than twice the increase in worker productivity as highway spending. A study by Leigh, Scott and Cleary (1999, Appendix K) concludes that transit increases economic growth in Colorado by about 4% over what would otherwise occur.

Supports Strategic Economic Development Objectives

Transit services can support specific strategic economic development objectives, such as tourism. For example, bus or trolley systems can be designed to serve visitors and provide access to major sport and cultural attractions, and historic train stations can be a catalyst for downtown redevelopment. This can be considered a special type of productivity gain often overlooked with conventional economic evaluation methods.

Transit System Efficiency Improvements

Many transit improvements increase system efficiency. Transit priority and improved payment systems increase operating speed and reduce delays, reducing operating costs. Many transit costs are fixed, so increased ridership reduces unit costs, particularly if ridership increases when there is excess capacity. Transit services experiences efficiencies and network effects. As per-capita ridership increases the system can expand, increasing service frequency, coverage, and operating hours, and transit can be more integrated with other transportation system features (for example, more businesses will choose to locate near transit). For these reasons, strategies that increase transit ridership can increase service efficiency and quality. Transit systems in cities with higher-quality transit systems and higher levels of per capita transit ridership tend to have lower transit operating costs, higher cost recovery, and lower per capita transportation expenditures than more automobile-dependent cities (Newman and Kenworthy, 1999; Litman, 2004a).

Measuring Economic Development Impacts

A variety of techniques can be used to measure different types of economic development impacts, including transportation-land use models, benefit-cost analysis, input-output models, economic forecasting models, econometric models, case studies, surveys, real estate market analysis and fiscal impact analysis (Cambridge Systematics, 1998; Lewis and Williams, 1999; Weisbrod, 2000; and HLB 2002; Leigh, Scott & Cleary, 1999; Smith and Gihring, 2003; Hass-Klau, Crampton and Benjari, 2004). The table below summarizes categories of benefits and how they can be measured.

Table 30 **Economic Development Impacts**

Category	Description	How It Can Be Measured
Employment and Business Activity	Increased employment and business activity resulting from expenditures on transit services.	Local expenditures on transit services times multipliers from a regional Input-Output table. "New" money brought into a region.
Consumer Expenditures	Consumer expenditures shifted from vehicles and fuel to more locally-produced goods.	Consumer expenditure shifts, evaluated using an Input-Output table to determine net change in regional employment and business activity.
Land Use Efficiencies	Increased accessibility and clustering, providing agglomeration efficiencies.	Changes in property values around transit stations.
Productivity Gains	Improved access to education and jobs, and reduced costs to businesses.	Methods described in *mobility*, *efficiency* and *land use* benefits sections, with emphasis on employment gains and businesses savings.
Strategic Economic Development	Transit facilities and services support strategic development objectives.	Role of transit in community's identity supporting strategic industrial development.
Transit System Efficiency	Reduced unit costs and improved services.	Estimates of per capita transportation cost savings provided by public transit services.

Transit improvements may provide various types of economic benefits and evaluation techniques.

It is important to avoid double-counting these benefits, or counting economic transfers as net economic gains. For example, the productivity gains of more accessible land use should be counted as land use benefits or economic benefits, but not both. On the other hand, it is appropriate to highlight ways transit supports particular economic development objective. For example, if area businesses have difficulty finding lower-wage employees, improving transit or providing special welfare-to-work services may help address this problem. Similarly, where downtown growth is constrained by traffic and parking congestion, transit improvements can be identified as part of the redevelopment program.

Impact Summary

Table 31 summarizes the categories of benefits and costs to consider in a comprehensive transit evaluation framework.

Table 31 **Transit Impacts**

Impact Category	Description
Transit Service Costs	**Financial costs of providing transit services**
Fares	Direct payments by transit users.
Subsidies	Government expenses to provide transit services.
Existing User Impacts	**Incremental benefits and costs to existing transit users**
Various	Changes in fares, travel speed, comfort, safety, etc. to existing transit users.
Mobility Benefits	**Benefits from increased travel that would not otherwise occur.**
Direct User Benefits	Direct benefits to users from increased mobility.
Public Services	Support for public services and cost savings for government agencies.
Productivity	Increased productivity from improved access to education and jobs.
Equity	Improved mobility that makes people who are also economically, socially or physically disadvantaged relatively better off.
Option Value/ Emergency Response	Benefits of having mobility options available, in case they are ever needed, including the ability to evacuate and deliver resources during emergencies.
Efficiency Benefits	**Benefits from reduced motor vehicle traffic.**
Vehicle Costs	Changes in vehicle ownership, operating and residential parking costs.
Chauffeuring	Reduced chauffeuring responsibilities by drivers for non-drivers.
Vehicle Delays	Reduced motor vehicle traffic congestion.
Pedestrian Delays	Reduced traffic delay to pedestrians.
Parking Costs	Reduced parking problems and non-residential parking facility costs.
Safety, Security and Health	Changes in crash costs, personal security and improved health and fitness due to increased walking and cycling.
Roadway Costs	Changes in roadway construction, maintenance and traffic service costs.
Energy and Emissions	Changes in energy consumption, air, noise and water pollution.
Travel Time Impacts	Changes in transit users' travel time costs.
Land Use	**Benefits from changes in land use patterns.**
Transportation Land	Changes in the amount of land needed for roads and parking facilities.
Land Use Objectives	Supports land use objectives such as infill, efficient public services, clustering, accessibility, land use mix, and preservation of ecological and social resources.
Economic Development	**Benefits from increased economic productivity and employment.**
Direct	Jobs and business activity created by transit expenditures.
Shifted expenditures	Increased regional economic activity due to shifts in consumer expenditures to goods with greater regional employment multipliers.
Agglomeration Economies	Productivity gains due to more clustered, accessible land use patterns.
Transportation Efficiencies	More efficient transport system due to economies of scale in transit service, more accessible land use patterns, and reduced automobile dependency.
Land Value Impacts	Higher property values in areas served by public transit.

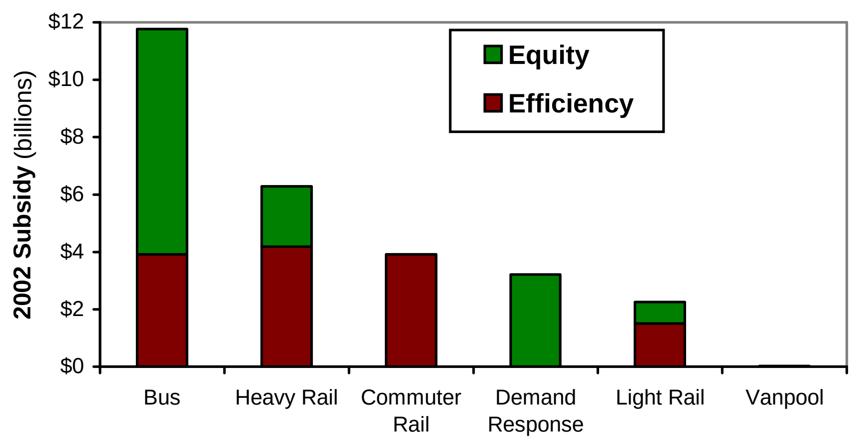
This table summarizes potential transit benefits and costs identified in this section. These are impacts to consider when evaluating a particular transit policy or project.

Evaluating and Quantifying Transit Benefits

Transit benefits can be divided into two major categories: *equity-oriented*, which result from the availability and use of transit by disadvantaged people, and *efficiency-oriented*, which result when transit substitutes for automobile travel. Some transit services are primarily *equity-justified*, others are primarily *efficiency-justified*, and many provide a combination of both. For example, demand response services, and bus transit in areas and times with low load factors, are primarily equity-justified, since they provide basic mobility and do little to reduce traffic congestion, facility costs or pollution emissions. Vanpooling, express bus and commuter rail services are primarily efficiency-justified, since they tend to serve middle- and higher-income patrons, and are intended to reduce congestion and other negative traffic impacts, although they incur some additional equity-justified costs to accommodate people with disabilities (such as special equipment and features for people in wheelchairs), which slightly increase their costs.

In general, transit in rural areas and smaller cities is primarily equity-justified, while conventional bus and rail service services in large cities provide both benefits. Within a particular system, efficiency-justified routes tend to have the highest cost recovery and lowest subsidy per passenger-mile. The figure shows the size of subsidies devoted to different modes, and categorizes them according to whether they are primarily equity- or efficiency-justified, assuming that 2/3 of bus service and 1/3 of light- and heavy-rail are primarily equity-justified. This suggests that about half of transit subsidies are equity-justified and half are efficiency-justified, although it is difficult to give a precise accounting since many benefits overlap.

Figure 13 **Transit Subsidies** (APTA, 2002)



About half of transit subsidies are equity-justified and about half are efficiency-justified.

The distinction between equity- and efficiency-justified subsidies is often important for transit evaluation. For example, it would be wrong to criticize equity-justified transit for failing to reduce traffic congestion or pollution emissions, and it would be wrong to criticize efficiency-justified transit for failing to serve lower-income travelers, since that is not their primary justification.

Many transit benefits are partly or completely ignored in conventional transport economic analysis, as summarized in the table below. In most cased, conventional evaluation only measures the direct benefits resulting from travel shifted from automobile to transit, but ignores indirect benefits that result when quality transit services leverage additional reductions in vehicle ownership and use. Most conventional evaluation only quantifies user travel time savings (for example, if grade-separated transit service increases transit travel speeds), but not the value of improved comfort (such as reduced crowding, more comfortable seats and better waiting areas), although by reducing unit (per-hour) travel time costs these measures are equivalent to increasing travel speeds.

Table 32 **Transit Benefits** (Litman, 2004)

Benefits	Description	Considered?
User benefits	Increased convenience, speed and comfort to users from transit service improvements.	Generally only increased speed.
Congestion Reduction	Reduced traffic congestion.	Direct but not indirect
Facility cost savings	Reduced road and parking facility costs.	Generally not
Consumer savings	Reduced consumer transportation costs, including reduced vehicle operating and ownership costs.	Operating costs, but not ownership costs
Transport diversity	Improved transport options, particularly for non-drives.	Sometimes, but not quantified.
Road safety	Reduced per capita traffic crash rates.	Direct but not indirect
Environmental quality	Reduced pollution emissions and habitat degradation.	Direct but not indirect
Efficient land use	More compact development, reduced sprawl.	Sometimes.
Economic development	Increased productivity and agglomeration efficiencies.	Direct but not indirect
Community cohesion	Positive interactions among people in a community.	Generally not
Public health	Increased physical activity (particularly walking).	Generally not.

"Indirect benefits" are benefits that result if quality transit reduces per capita vehicle ownership and use.

The quantification of transit benefits is complicated by the fact that some impacts overlap. For example, direct user savings and benefits are partly capitalized into land values around transit stations, so it would not be appropriate to simply add all of those benefits together. But many transit benefits are indirect or external and so are not perceived by users or capitalized in property values, as illustrated in the Table 33.

Table 33 **Transit Benefits**

Benefits	Capitalized In Property Values
User benefits	Yes
Congestion Reduction	Direct yes, indirect no
Facility cost savings	Direct yes, indirect no
Consumer savings	Direct yes, indirect no
Transport diversity	Direct yes, indirect no
Road safety	Mostly not
Environmental quality	Mostly not
Efficient land use	Some
Economic development	Some
Community cohesion	Some
Public health	Possibly

Only a portion of transit benefits are directly perceived by users and so reflected in land values.

In addition, transit systems experience economies of scale: as more people use the service becomes more efficient overall and benefits increase exponentially. As a result, marginal benefits are greater than average benefits. There is also land use economies of agglomeration leveraged by transit, particularly high quality rail transit that provides a catalyst for more compact, mixed, mulit-modal community development. Large central business districts, which provide significant, unique economic benefits, simply could not exist without high quality transit services. These additional economic benefits are not capitalized in land values or measured through conventional indicators.

For these reasons it would be wrong to assume that all, or even most transit benefits are capitalized in property values. Although more research is needed to better quantify the distribution of costs and benefits, it is likely that most are not directly perceived by users, so total benefits are far greater than what is measured through property value impacts.

Comparing Transit and Automobile Costs

Comparisons between transit and other modes should account for the type of service and their planning objectives. For efficiency-justified service (provided to minimize economic costs such as congestion, facility costs, accidents and pollution) transit and automobile transport can be compared using measures of cost effectiveness, such as costs per passenger-mile or benefit/cost ratio, to identify the least-cost option. In that case, there is no particular reason to subsidize transit more than automobile travel.

However, for equity-justified service (providing basic mobility to disadvantaged people) there are reasons to subsidize transit more than automobile travel, because transit bears additional costs to accommodate people with disabilities, and many non-drivers have low incomes, so greater public subsidies are justified on equity grounds. Since many of these people cannot drive, analysis must include the cost of a driver, so transit should be compared with taxi costs, or a combination of taxi and chauffeured automobile travel, taking into account the value of time by family members and friends who drive.

Per Passenger-Mile

When measured per *passenger-mile*, transit subsidies often appear large. Transit subsidies average about 60¢ per passenger-mile, about 40 times larger than automobile roadway subsidies (Litman, 2003). About half of transit subsidies are equity-justified. Considering only efficiency-justified subsidies, transit subsidies are about 20 times greater than automobile roadway subsidies. Automobile use requires other public expenditures besides roads, include traffic services (policing, emergency services, street lighting, etc.) and publicly subsidized parking. These are estimated to total at least 6¢ per passenger-mile. This implies that transit subsidies are 10 times greater than automobile subsidies, or 5 times efficiency-justified automobile subsidy.

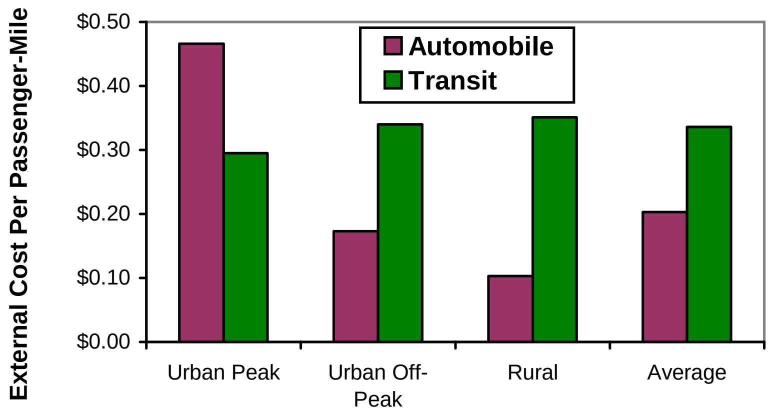
Table 34 **Automobile and Transit External Costs Per Passenger-Mile** (Litman, 2003)

	Urban Peak		**Urban Off-Peak**		**Rural**		**Average**	
	Average Car	Diesel Bus	Average Car	Diesel Bus	Average Car	Diesel Bus	Average Car	Diesel Bus
Average Occupancy	*1.1*	*25.0*	*1.5*	*8.0*	*1.5*	*5.0*	*1.42*	*10.20*
Operating Subsidy	0.000	0.250	0.000	0.250	0.000	0.250	0.000	0.250
Crash	0.032	0.008	0.023	0.025	0.023	0.040	0.025	0.028
External Parking	0.109	0.000	0.027	0.000	0.013	0.000	0.038	0.000
Congestion	0.155	0.014	0.013	0.005	0.000	0.000	0.036	0.005
Road Facilities	0.015	0.003	0.011	0.009	0.007	0.008	0.010	0.007
Land Value	0.022	0.001	0.016	0.003	0.016	0.005	0.017	0.003
Traffic Services	0.014	0.001	0.007	0.001	0.003	0.001	0.007	0.001
Air Pollution	0.056	0.007	0.035	0.020	0.011	0.014	0.029	0.015
Noise	0.009	0.002	0.007	0.006	0.003	0.005	0.006	0.005
Resource Externalities	0.026	0.006	0.017	0.016	0.014	0.022	0.018	0.017
Barrier Effect	0.014	0.002	0.007	0.003	0.003	0.003	0.007	0.003
Water Pollution	0.012	0.001	0.009	0.002	0.009	0.003	0.009	0.002
Totals	*$0.464*	*$0.295*	*$0.172*	*$0.340*	*$0.102*	*$0.351*	*$0.202*	*$0.336*

This table summarizes external costs of automobile and transit in mills (thousandths of a dollar).

Vehicle travel imposes other external costs, including congestion, parking subsidies, crash risk imposed on other road users, and pollution emissions. Table 34 indicates estimates of automobile and transit external costs under various travel conditions. Figure 14 illustrates the totals. These costs are particularly high under urban-peak conditions, which is where transit tends to be most cost-effective. As a result, transit is often justified under urban-peak conditions on efficiency grounds. In addition, a certain amount of transit service is justified under all conditions to provide basic mobility.

Figure 14 **Transit and Automobile External Costs** (Litman, 2003)



This figure compares estimated average external costs for automobile and transit under various travel conditions, including operating subsidies, congestion, road, parking subsidies, accident externalities and pollution emissions. Transit has lower costs under urban peak conditions.

Taxi operating costs (for vehicles, drivers and business expenses) average about $2.25 per mile, plus external costs of 20-50¢ per mile (the same as automobile travel). Transit subsidies are therefore about a quarter of taxi service costs for the same trips, indicating that transit is often more cost effective than other options available to non-drivers.

Per Capita

For equity analysis it can be helpful to compare costs per capita. Transit dependent people tend to travel fewer vehicle-miles per year, so even if transit costs are higher than those of driving per passenger-mile, they may be lower per capita. For example, a non-driver who rides transit 3,000 miles annually with subsidies averaging 60¢ per mile receives $1,800 in total subsidy, while an average motorist imposes external costs averaging $2,900 annually (Litman, 2003). Similarly, certain areas, particularly large cities, tend to have less automobile travel and more transit travel. As a result, transit subsidies can be justified on horizontal equity grounds, to insure that non-drivers and urban areas receive their fair share of transport funding. For example, in British Columbia in 1995, provincial roadway expenditures average only $77 annually per capita in the Vancouver region but $250 in other regions. Only by providing significant transit funding do cities residents receive a fair share of provincial or state transport funds.

Economies of Scale and Second-Best Pricing
Subsidies are justified for goods that experience economies of scale in production, that is, marginal costs are lower than average costs (Vickrey, 1994, pp. 197-215). Transit service tends to have a declining cost structure, since many costs are fixed, so increased ridership reduces unit costs and increases service scope and frequency. In addition, existing transportation markets are distorted in ways that favor automobile travel, including subsidized parking, underpriced road space, fixed insurance and vehicle registration fees, unpriced pollution emissions, and zoning codes that limit urban density and infill development. In a more economically efficient market motorists would have more incentive to use transit, particularly under urban-peak conditions. Until such reforms are implemented, transit subsidies that improve service and reduce fares may be justified on *second-best* grounds, to help reduce transportation costs such as congestion, parking and accidents. Both marginal and second-best pricing analysis indicate that it is often economically efficient to subsidize transit and implement other rider incentives.

Project-Specific Comparisons
The analysis above compares transit and automobile travel using generic, average values, but when evaluating transit projects and comparing them with other options in a particular planning situation it is best to use specific marginal costs and benefits. This can identify whether transit is most cost-efficient, and can help design transit projects to maximize net benefits. Marginal costs are often lower than average costs for transit services. For example, once a decision is made to provide transit to provide basic mobility to non-drivers there is often little incremental cost to carrying more riders.

Cost Comparison Summary
Table 35 summarizes different ways of comparing transit and automobile costs. Considering just direct public financial subsidies, transit appears far more costly. However, when efficiency-justified transit costs are excluded, and other external costs are considered, transit turns out to have lower external costs than automobile travel, particularly under urban-peak conditions.

Table 35 **Comparing Transit And Automobile Costs Per Passenger-Mile**

Perspective	Transit Versus Automobile Cost Ratio	
	Total	Efficiency-Justified
Transit subsidy versus roadway subsidy.	40:1	20:1
Transit subsidy versus government expenditures on roads and traffic services.	10:1	5:1
Total average external costs of transit and automobile.	1.5:1	0.75:1
Urban-Peak external costs of transit and automobile.	0.5:1	0.5:1
Per capita annual external costs of transit and automobile users.	0.6:1	0.3:1
Marginal cost of addressing various transportation problems.	Transit Often Cheapest	Transit Often Cheapest
Project-specific analysis.	Varies	Varies

This table summarizes different ways of comparing transit and automobile costs. Considering just direct public subsidies, transit appears more costly than automobile travel, but as more impacts are considered transit often turns out to be less costly, particularly under urban-peak conditions. These are generic estimates to indicate the general magnitude of costs, more detailed analysis is needed to determine costs in a particular situation.

Perspectives

Transit and automobile costs can be compared from various perspectives, such as these three.

Consumers

Although most North American adults reply primarily on automobile transportation, many still experience periods in life they can benefit from having transit available, including when they are too young to drive, if they have limited incomes, if they have a disability that limits driving (which is particularly common during old age), when their vehicle fails or for any reason they are not allowed to drive, if a family member of friend would need to be chauffeured, during special events that attract large crowds, and if they commute to a destination with significant congestion or parking costs.

From consumers perspective transit can be a cost effective investment. Residents of communities with more balanced transport systems spend hundreds of dollars less each year on transportation (transit and vehicle costs) compared with residents of automobile dependent cities (McCann, 2000), so return on investment can be large. For example, if $100 annual per capita transit tax investments allows average households to reduce their vehicle costs just 2%, the household saves money overall. In fact, communities with large, well-established rail transit systems spend an average of $136 annually per capita on transit subsidies, $90 more than in cities with only basic bus service, but consumers in rail transit cities spend about $447 less annually on transportation, although their incomes are higher which normally increases such expenditures (Litman, 2004a). This indicates that each dollar invested in high quality transit provides about $5 in direct consumer savings, plus various other savings and benefits such as reduced parking costs, reduced accidents and improved mobility options.

Transit Can Make You A Millionaire

Here is a strategy that can provide a million dollars to a person with an average income, and it is enjoyable, healthy and ethical. Simply minimize your driving expenses and invest the savings. After a few decades you'll be rich. It's as simple as that.

Most households can reduce their vehicle expenditures. For example, owning and operating a typical new luxury car, SUV or van costs about $8,000 a year, and most households own multiple vehicles. If you buy a reliable used car, share it with other family members, and minimize your driving by using transit, cycling and walking when possible, you can reasonably cut your vehicle expenses in half. Although you'll lead a less mobile lifestyle, you'll enjoy greater financial freedom.

What happens if you invest the $4,000 annual savings at 7% annual return? In ten years you have $55,266, in twenty years you have $163,982, and in less than forty-four years you have a million dollars. In other words, excessive car costs waste a million dollars of accumulated wealth over a typical working lifetime.

Perhaps you have other priorities besides retiring rich. You can use the savings to buy a nicer home, put children through college, travel, or work fewer hours. This alternative is not transportation deprivation. You can still have a household car available when you need it, you simply can't own a particularly flashy vehicle or lead an extremely automobile-dependent lifestyle.

Business

Public transit can benefit businesses by improving employee access, reducing costs and supporting community land use and economic development. Below are examples of benefits to various types of businesses:

- *Service-Oriented Business.* Public transit can expand the pool of available workers and provide a fall-back option for commuters who normally drive when their vehicles are for any reason unavailable. This is particularly important for industries that hire numerous lower-wage workers, such as hospitality and retail businesses.
- *Downtown Developer.* Transit is important for downtown economic development. It reduces parking costs and allows higher densities and more design flexibility than would occur if visitors all arrived by car.
- *Tourist Attraction.* Transit can support tourism by providing mobility for visitors who arrive without a car, by reducing the economic and aesthetic costs of providing visitor parking, and by providing commute transportation to lower-wage employees.
- *Small Retail Business*. Downtowns offer a unique retail environment. Transit service reinforces the economics and ambiance of downtown by reducing automobile traffic and parking problems, and bringing a critical mass of customers into a walkable commercial area.
- *Manufactures, Shippers and Service Companies.* Public transit benefits businesses that use roadways by reducing traffic and parking congestion.

Public Officials and Taxpayers

Transit services and support strategies such as commute trip reduction programs and transit oriented development can provide government savings and achieve public objectives.

- *Transportation Agency.* Transit improvements are often the least-cost way to improve mobility, reduce urban traffic and parking congestion, and address particular problems, such as congestion during roadway construction projects or special events.
- *Social Services.* Transit services support public services by providing access to medical services, education and employment by disadvantaged populations.
- *Schools and Colleges*. Public transit can make education more affordable and available to disadvantaged students, and helps reduce traffic and parking problems around schools and campuses.
- *Economic Development*. Transit services support economic development, by reducing government and business costs, improving access to jobs, and supporting various economic development efforts such as urban redevelopment and tourism.
- *Land Use Planning*. Transit can help support strategic land use objectives, such as redevelopment of existing urban communities and reduced sprawl.
- *Special Events.* Transit can help address traffic and parking problems that occur during major sport and cultural events.
- *Environmental Quality*. Public transit can help achieve energy conservation, pollution emission reduction and greenspace preservation objectives.

Motorists

Critics sometimes assume that there is a conflict between the interests of motorists and transit users. They often claim that public transit receives an excessive portion of transportation funding, and challenge the use of vehicle user fees to fund public transit services. But motorists have many reasons to support public transit, as listed below.

- *Congestion Reduction.* Quality transit service that is attractive to discretionary travelers can be an effective way to reduce traffic and parking congestion.
- *Roadway and Parking Facility Cost Savings.* When all costs are considered, transit improvements are often cheaper than increasing road and parking facility capacity. This reduces costs to governments and businesses.
- *Improve Choice.* Even people who don't currently use transit may value having it as a mobility option for emergencies and future use, similar to the value that ship passengers place on having a lifeboat, even if they don't use it.
- *Consumer Cost Savings.* High-quality transit service, and transit-oriented land use, can provide hundreds or thousands of dollars a year in savings per household (McCann, 2000).
- *Reduced Chauffeuring.* Quality transit service can reduce motorists' need to give rides to non-driving friends and family members.
- *Safety Benefits.* Transit travel tends to have lower crash risk than automobile travel, reducing crash risks to transit riders and other road users.
- *Efficient Land Use.* Some land use patterns, including large commercial centers, multimodal neighborhoods and some types of resorts, are only feasible with high quality transit service.
- *Equity.* Transit provides basic mobility for people who are economically, physically and socially disadvantaged.
- *Economic Development.* Expenditures on transit tend to provide much more employment and regional business activity than consumer expenditures on automobiles and fuel.
- *Environmental Benefits.* Transit consumes fewer resources and causes less pollution than automobile travel.

Critics sometimes imply that it is hypocritical or unfair for people to support transit if they don't currently use it (e.g., "Supporters simply want transit for other people to use, so they can continue driving"). But there is no reason that support for transit should be limited to currently users. It is both rational and moral for motorists to support transit to improve mobility for others, reduce traffic and parking congestion, and provide a transport option that they may use in the future. Put another way, over a typical lifecycle most people have periods when they rely on public transit. Non-users can support transit as a way to insure it will be available when they will need it in the future.

Common Errors Made When Comparing Transit and Automobile Transport

Below are common errors made when comparing transit and automobile costs and benefits. For more discussion see Litman and Greenberg, 2000 and "Comprehensive Planning," VTPI, 2004.

- *Confusing efficiency and equity objectives.* Because transit services are justified for both efficiency and equity objectives, it is important to consider these objectives separately in economic analysis. Some efficiency-justified services may seem inequitable (for example, premium services to attract commuters out of their cars), and some equity-justified services may seem inefficient (such as special services and features to accommodate people with disabilities, and off-peak service to provide basic mobility).
- *Comparing average rather than marginal costs.* When comparing automobile and transit investments, some analysts use generic average costs, ignoring the greater efficiency of transit and higher costs of automobile travel under urban-peak conditions.
- *Ignoring parking costs.* Economic analysis often ignores the parking cost savings that result from reduced automobile ownership and use.
- *Underestimating vehicle cost savings.* Economic analysis often considers only fuel, oil, tire wear and tolls when calculating the savings from reduced driving, ignoring additional savings from reduced vehicle ownership and mileage-based depreciation savings.
- *Undervaluing safety and health benefits.* Safety benefits from reduced accidents, and health benefits from increased walking are often overlooked.
- *Ignoring transportation diversity benefits.* There are benefits to having a diverse transport system that are often overlooked, including improved mobility for non-drivers, consumer savings and choice, increased efficiency, increased system flexibility and resilience.
- *Ignoring non-drivers interests.* Transportation planning sometimes assumes that everybody has access to an automobile, giving little consideration to the needs of non-drivers, or the negative impacts that increased vehicle traffic and automobile-oriented land use have on pedestrians, cyclists and transit users.
- *Ignoring generated traffic impacts*. Failure to consider the effects of generated traffic tends to overstate the benefits of highway capacity expansion and understate the benefits of alternative solutions, particularly grade separated transit (Litman, 2001).
- *Ignoring strategic land use objectives.* Transit tends to support land use objectives such as reduced sprawl and urban redevelopment.
- *Ignoring construction impacts.* Transport projects, particularly highway construction, often cause delays and accident risk, and displace residents and businesses. These can offset a significant portion of the project benefits (McCann, et al, 1999).
- *Undervaluing congestion reductions.* Transit can provide significant long-term congestion reductions when it is faster than driving, but this impact is often overlooked.
- *Ignoring consumer preferences.* Some people prefer using alternative modes and will choose them over driving even if they are slower. This benefit is sometimes overlooked, and lower travel time costs for such travelers are sometimes overlooked in modeling.
- *Ignoring strategies for increasing transit benefits.* A transit option that does not appear justified under current conditions may become cost effective if implemented as part of a coordinated program that includes ridership incentives and transit oriented development

Evaluating Transit Criticism

There is considerable debate over the merits of transit. Critics argue that it is ineffective at improving transportation system performance and is wasteful, but their analysis reflects various omissions, errors and misrepresentations. *Evaluating Rail Transit Criticism* (Litman, 2005a) and various documents cited in it examine these criticisms in detail. Below are some key points.

- Critics tends to ignore or understate many benefits of transit, and underestimates the full costs of increasing automobile traffic on congested urban corridors. For example, they compare the costs of rail transit projects and average highway expansion costs, although rail projects include vehicles, tracks and (sometimes) parking facilities, and highway costs are much higher in dense urban area. An accurate analysis compares the costs of urban rail with the full costs of expanding roadway capacity, owning and operating automobiles, and providing parking on the same congested urban corridors.
- Critics argue that North Americans will not ride transit, and that North American cities are unsuited to efficient transit systems. But experience in several North American cities show that with quality transit services and supportive policies transit ridership will grow, and transit can be cost effective compared with other transportation improvement options.
- Critics are wrong when they claim that rail transit does not reduce traffic congestion. There is plenty of evidence that per capita congestion costs are lower on corridors with high quality rail transit.
- Critics claim that transit carries too few travelers to solve regional transportation problems. But transit operates on the most congested routes where even a small reduction in traffic volumes can provide significant road, parking and vehicle cost savings.
- Critics argue that transit is too slow to be useful or attractive. But on congested urban, automobile travel is also slow due to congestion, so transit trips are often competitive. In addition, many consumers tend to consider time spent traveling by quality transit (passengers have a seat, vehicles are comfortable, safe and quiet) to have less cost than the same amount of time spent driving in congested conditions.
- Critics claim that transit is not a cost effective way to reduce traffic congestion, reduce air pollution, improve mobility for non-drivers, etc. They may be correct if transit is evaluated based on just one objective, but it provides a variety of benefits. When all costs and benefits are considered, rail transit is often most cost effective overall.
- Critics claim that rail transit is excessively subsidies, but rail transit subsidies are often lower than subsidies for bus transport, and far lower than the total external costs of automobile transport under urban travel conditions. Transit subsidies are justified for the sake of equity, to offset various market distortion, due to economies of scale, or to help achieve a strategic planning objective, factors that critics generally ignore. Although it would not be cost effective to provide rail transit service everywhere, when all costs and benefits are considered, rail transit is often the most cost effective way to improve transportation on major urban travel corridors.
- Critics claim that it would be cheaper to subsidize automobiles than to provide transit services, but they overlook many important factors, as discussed in the following section).

Debates about the value of transit often reflect differences in the scope and definition of impacts (benefits and costs). Transit services and improvements should generally be evaluated based on their *total* benefits and costs, rather than a few performance indicators such as dollars per reduction in congestion delay or ton of emissions. This can be done formally, by monetizing (measuring in monetary units) all impacts to calculate *net present value*, or less formally using some sort of matrix of performance indicators (Litman, 2001a).

At a minimum, these impacts should include congestion reduction, road and parking cost savings, consumer cost savings, reduced crash costs, energy conservation and emission reduction benefits, improved mobility for non-drivers, and support for strategic planning objectives such as reduced impervious surface, urban redevelopment and economic development, as discussed in this report. Quantification can be difficult because so many of the benefits and a few of the costs of transit, particularly rail transit, do not lend themselves to be easily measured and monetized. For example, transit improvements and transit-oriented development tend to improve accessibility for disadvantaged populations, an equity objective. It is difficult to place a dollar value on this benefit, although most people would probably agree that it is important to consider when evaluating options. Similarly, it can be difficult to quantify the full benefits of energy conservation (what value to put on reduced dependency on imported oil) although most people will probably agree that it is significant.

It is clearly wrong to evaluate public transit based on just one or two performance indicators, such as congestion or air pollution reduction, just as you wouldn't evaluate a possible house to purchase based only on the size of its bedroom or the quality of its appliances. A house provides a complex set of services. So does a transportation system. Evaluation must be multi-faceted, recognizing the full range of direct and indirect impacts. One of the greatest challenges of good decision-making is the temptation to focus on easy-to-measure impacts at the expense of more-difficult-to-measure impacts.

Rail transit and transit-oriented development are often criticized because their full benefits take many years to be achieved, since rail is built one link at a time, and transit-oriented development requires changing land use patterns. But they can provide diverse benefits and these benefits are extremely durable once implemented. Rail transit and TOD therefore provides a long-term legacy of increased accessibility and community livability for the future. A short-term perspective will therefore undervalue these strategies.

Is It Cheaper To Subsidize Cars Instead Of Transit?

Some critics argue it would be cheaper to subsidize car ownership for low-income people than transit service. For example, Castelazo and Garrett (2004) calculate it would be cheaper to provide free cars to the 14% of St. Louis rail transit riders that lack automobiles, than to subsidize that service. Cox (2004) claims that carsharing subsidies for non-drivers would be cheaper than U.S. transit subsidies. However, such claims tend to overlook important factors (Litman, 2005a).

- Transit is subsidized for several reasons besides providing mobility to lower-income travelers, including congestion reduction, road and parking facility cost savings, consumer cost savings, increased safety, pollution reduction and support for strategic development objectives. Only a small portion of transit subsidies could efficiently or equitably be shifted to any one of these objectives.
- Many transit riders cannot or should not drive. They are too young, disabled, or prohibited from driving. Subsidizing cars instead of transit service would not solve their mobility problems, and would tend to increase higher-risk driving. It is easier to reduce driving by high-risk motorists in communities with good transit systems, for example, by delaying teenage vehicle ownership, revoking driving privileges for dangerous drivers, and reducing vehicle use by elderly residents, which helps explain the much lower per capita traffic fatality rates in areas with good transit service.
- Substituting car ownership for transit service is more expensive than proponents claim. Increased vehicle traffic on busy urban corridors would significantly increase traffic congestion, road and parking costs, accidents, pollution and other external costs.
- Eliminating scheduled transit service would force riders who cannot drive to use demand-response or taxi services, which have far higher costs. Cox assumes this could be accommodated by doubling demand-response funding, but since demand response services only provide 1.4% of total transit passenger-miles, doubling its funding could not compensate for reducing the other 98.6% of services. People tend to significantly increase their travel when they shift from transit to having an automobile, so even if per-mile costs decline, per-user costs would likely increase.
- There are substantial practical problems with offering free cars or carshare subsidies to low-income people who currently rely on public transit. Low-income transit riders are not a distinct, identifiable group, they consist of a much larger group, many of whom use transit part-time, or who sometimes do not own an automobile. Rather than giving 7,700 households a car, it would be necessary to offer a much larger number of households a part-time car, with provisions that account for constant changes in vehicle ownership and travel status, and for the increased travel that occurs when non-drivers gain access to an automobile. Like any subsidy program, it would face substantial administrative costs and require complex rules to determine who receives a subsidy and how much each user is allocated in a way that seems fair and effective at achieving its objectives. It would create perverse incentives, rewarding poverty and automobile dependency.
- Transit in general and rail transit in particular can provide a catalyst for mixed-use, walkable urban villages and residential neighborhoods where it is possible to live and participate in normal activities without needing an automobile. This is particularly beneficial to non-drivers. Subsidizing cars rather than transit services would cause an additional harm to transportation disadvantaged people, by stimulating urban sprawl and automobile dependency.

Rail Versus Bus Transit

There is considerable debate over the relative merits of bus and rail transit (Pascall, 2001; GAO, 2001; Warren and Ryan, 2001; Demery and Higgins, 2002; Ben-Akiva and Morikawa, 2002; Thompson and Matoff, 2003; Hass-Klau, et al., 2003; Litman, 2004a; Steer Davies Gleave, 2005; Currie, 2005; Vuchic, 2005; NJARP, 2006; LRN, 2006). Key issues are discussed below.

Table 36 summarizes some performance differences between various forms of transit. Of course, actual performance varies depending on design and conditions.

Table 36 **Transit Performance Factors** (Steer Davies Gleave, 2005, Table 3.1)

Standard	Conventional Bus	Double-deck Bus	Articulated Bus	LRT	Two-Car Trams
Length	10m	12m	18m	24.5m	2 x 30m
Width	2.5m	2.5m	2.5m	2.55m	2.65m
Passenger Capacity	75	105	125	160	350
Seating	35	95	50	60	150
Standing	40	10	75	100	200
Maximum Hourly Capacity	4,500	6,300	7,500	9,600	21,000

Advantages of Rail

Proponents argue that rail transit provides superior service quality that attracts more discretionary users (people who have the option of driving). Rail can carry more passengers per vehicle and requires less land per peak passenger-trip, and so tends to be more cost effective than bus on high-density corridors (Bruun, 2005). Voters seem more willing to support funding for rail than bus service. Rail causes less noise and air pollution than diesel buses. As described earlier, rail tends to have higher demand within its service area (Pushkarev and Zupan, 1977; Henry and Litman, 2006), although this may partly reflect factors such as frequent service, grade separation and accessible stations, which can be provided by Bus Rapid Transit systems (Currie, 2005). Rail tends to have much greater impact on land use patterns – rail transit stations often serve as a catalyst for transit oriented development, which provides additional economic, social and environmental benefits (Currie, 2006).

Accessibility and Mobility
When comparing bus and rail it is important to appreciate the difference between mobility and accessibility (Litman, 2003a). *Mobility* refers to physical movement. *Accessibility* refers to peoples' ability to obtain desired goods, services and activities, which is affected by mobility and land use patterns. Automobiles offer users a high level of mobility, but heavy automobile traffic degrades other forms of mobility (particularly walking) and encourages dispersed land use patterns. Bus transit can provide a high level of mobility, with direct service to many destinations, but has minimal land use impacts. Rail transit provides moderate mobility and is often a catalyst for more accessible land use patterns, call *transit-oriented development*. Rail transit is therefore most attractive in terms of accessibility rather than mobility.

Advantages of Bus

Bus advocates argue that bus service is cheaper and more flexible, that buses can be designed to be nearly as fast and comfortable as rail, and that much of the preference for rail reflects prejudices rather than real advantages. Bus transit can serve a greater area, and so can attract greater total ridership than rail with comparable resources, particularly in areas with dispersed destinations. Some argue that rail investments (which tend to benefit higher-income people) drain funding from bus service (which tends to benefit lower-income, transit-dependent people), and so are inequitable, although this is not true if rail projects receive special funding that increases total transit budgets, and some rail lines carry large numbers of lower-income riders.

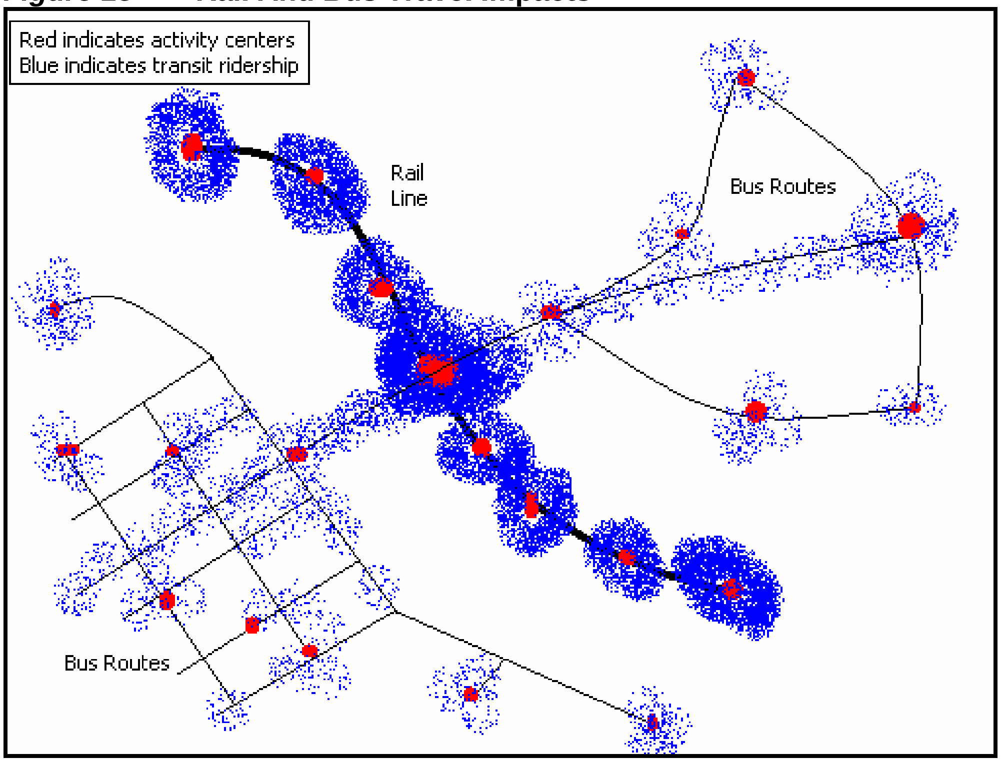
Summary of Rail Versus Bus

Key differences between bus and rail transit are summarized below. Rather than a debate about whether or not rail is overall superior to bus, it is generally better to consider which is most appropriate in a particular situation. Bus is best serving areas with more dispersed destinations and lower demand. Rail is best serving corridors where destinations are concentrated, such as large commercial centers and mixed-use urban villages (Kuby, Barranda and Upchurch, 2004). Rail tends to attract more riders within a given area, but buses can cover more area, so overall ridership impacts depend on the specific situation. Both can become more efficient and effective at achieving planning objectives if implemented with supportive policies that improve service quality, create more supportive land use patterns and encourage ridership.

Bus	Light Rail
Flexibility. Bus routes can change and expand when needed. For example, routes can change if a roadway is closed, or if destinations or demand changes. Requires no special facilities. Buses can use existing roadways, and general traffic lanes can be converted into a busway. More suitable for dispersed land use, and so can serve a greater rider catchment area. Several routes can converge onto one busway, reducing the need for transfers. For example, buses that start at several suburban communities can all use a busway to a city center. Lower capital costs. Is used more by people who are transit dependent, so bus service improvements provide greater equity benefits.	Greater demand. Rail tends to attract more discretionary riders than buses. Greater comfort, due to larger seats with more legroom, more space per passenger, and smother and quieter ride. More voter support for rail than for bus improvements. Greater maximum capacity. Rail requires less space and is more cost effective on high volume routes. Greater travel speed and reliability, where rail transit is grade separated. More positive land use impacts. Rail tends to be a catalyst for more accessible development patterns. Increased property values near transit stations. Less air and noise pollution, particularly when electric powered. Rail stations tend to be more pleasant than bus stations, so rail is preferred where many transit vehicles congregate.

Rail transit can only provide service to a limited number of stations. Those stations tend to stimulate more intense development, with increased density (residents, employees and business activity per acre), higher per capita transit ridership and walking trips, and lower per capita vehicle ownership and trips. Bus transit can serve more destinations, including some dispersed, suburban activity centers, but attracts fewer riders per capita, and by itself has little or no effect on land use patterns. Which will attract the most riders and be most cost effective depends on the circumstances: rail tends to attract more riders in the area it serves, but buses can directly serve more destinations over a larger area.

Figure 15 **Rail And Bus Travel Impacts**



This illustrates differences between rail and bus transit travel impacts. Rail provides service to a limited number of stations. Those stations can stimulate more intense development, with increased population and employment density, higher per capita transit ridership and walking trips, and lower per capita vehicle ownership and trips. Bus transit can serve more destinations, including some dispersed, suburban activity centers, but attracts fewer riders per capita, and by itself has little or no effect on land use patterns. Both types of transit can attract more riders and become more effective if implemented with supportive transport and land use policies.

In a detailed analysis Bruun (2005) found that in a typical case, both Light Rail Transit (LRT) and Bus Rapid Transit (BRT) have lower operating costs per passenger-space-kilometer during base periods than regular buses. In some cases providing additional peaks service costs more using BRT than LRT. For trunk line capacities below about 1,600 spaces-per-hour, BRT tends to be cheapest, while above 2,000 spaces-per-hour BRT headways become so short that traffic signal priority becomes ineffective, reducing service efficiency and increasing unit costs. The marginal cost of adding off-peak service is lowest for LRT, higher for BRT, and highest for regular buses.

Rail and bus transit systems are generally integrated, with buses providing local service and servicing more dispersed destinations, and rail providing service along the highest density corridors. Both types of transit can become more effective if implemented with supportive transport and land use policies.

Rail transit can be compared to a luxury vehicle: it costs more initially but provides higher quality service and greater long-run value. As consumers become wealthier and accustomed to higher quality goods it is reasonable that they should demand features such as more leg-room, comfortable seats, smoother and quieter ride (and therefore better ability to read, converse, and rest), and greater travel speed associated with grade-separated transit. The preference of rail over bus can be considered an expression of consumer sovereignty, that is, people's willingness to pay extra for more amenities. Analysis of qualitative factors such as rider comfort is needed to evaluate the full value of rail transit.

Strategies To Increase Transit Benefits

Simply operating transit service cannot maximize transit investment benefits. Benefits tend to increase if transit is implemented with support strategies that increase efficiency and attract riders. Examples of these support strategies are described below. More information is available in the *Online TDM Encyclopedia* (www.vtpi.org/tdm), Stanley and Hyman (2005), and TranSystems (2005).

Transit Priority

There are various ways to help transit vehicles avoid congestion delays and travel faster, including managed lanes, traffic signal preemption, special intersection design, and preferred loading and parking locations. These strategies increase operating efficiency (since transit vehicles can carry more passengers in a given period of time) and make transit more competitive with automobile travel.
Impacts: Transit priority provides direct benefits to current transit users, and will typically shift 4-30% of current automobile trips to transit or vanpools, depending on conditions. The greater the time savings, the more mode shifting is likely to occur. Pratt (1999) provides detailed discussion of the travel effects of busway and HOV facilities.

Parking Management

Parking management can be an effective way to increase transit use. Parking management includes "parking cash out" (employees who receive free parking have the option of choosing cash or a transit subsidy instead), "unbundling" (building renters only pay for the amount of parking they actually want), and more flexible parking requirements that allow developers to supply less parking where appropriate.
Travel Impacts: Parking pricing is one of the most effective ways of reducing automobile trips. Cost-based parking pricing (parking fees set to recover parking facility costs) typically increases transit ridership by 10-30%, depending on the previous level of transit ridership and the range of travel options available.

Commute Trip Reduction Programs

Commute Trip Reduction (CTR) programs give commuters resources and incentives to reduce their automobile trips. CTR programs typically include some of the following:

- Commuter Financial Incentives (Parking Cash Out and Transit Allowances).
- Rideshare Matching.
- Parking Management.
- Alternative Scheduling (Flextime and Compressed Work Weeks).
- Telework (for suitable activities).
- Guaranteed Ride Home.
- Walking and Cycling Encouragement.

Travel Impacts: Worksites with CTR programs that lack financial incentives typically experience 5-15% reductions in commute trips. Programs that include financial incentives (such as transit subsidies or parking cash out) can achieve 20-40% reductions.

Campus and School Transport Management Programs

Campus Transport Management programs are coordinated efforts to improve transportation options and reduce trips at colleges, universities and other campus facilities. This often includes free or significantly discounted transit passes to students and sometimes staff (called a "UPASS").
Travel Impacts: Comprehensive campus transportation management programs can reduce automobile trips by 10-30% and increase transit ridership 30-100%.

Marketing and User Information

Transit marketing and user information includes market surveys, improved route schedules and maps, wayfinding information, and other types of information.
Travel Impacts: Given adequate resources, marketing programs can often increase use of alternative modes by 10-25% and reduce automobile use by 5-15%. About a third of the reduced automobile trips typically shift to public transit.

Nonmotorized Improvements

Nonmotorized modes (walking and cycling) are important travel modes in their own right and provide access to public transit. Nonmotorized improvements can leverage shifts to transit. There are various ways to further improve and encourage nonmotorized transport:

- Improved sidewalks, crosswalks, paths and bikelanes.
- Correcting specific roadway hazards to nonmotorized transport.
- Traffic calming to control automobile traffic in particular areas.
- Bicycle parking and storage.
- Address security concerns of pedestrians and cyclists.

Travel Impacts: In many situations inadequate nonmotorized travel conditions are a major constraint to transit travel, so nonmotorized improvements may increase transit ridership 10-50% over what would otherwise occur.

Transit Oriented Development

Transit Oriented Development (TOD) refers to communities designed to maximize access by public transit, with clustered development and good walking and cycling conditions (Cervero, et al, 2004).
Travel Impacts: Residents of TODs typically reduce single-occupant vehicle commuting by 15-30%, about half of which shifts to transit. Impacts depend on specific design features, and other geographic and demographic factors.

Least Cost Planning

Current transportation planning practices are biased in various ways that favor highways and parking investments over transit (Beimborn, and Puentes, 2003; "Comprehensive Transport Planning," VTPI, 2004). More neutral planning provides various benefits, including increased efficiency and equity.
Travel Impacts: Difficult to predict, but probably significant.

Evaluation Examples

This section uses various examples to illustrate different types of transit evaluations. A spreadsheet computer model available at www.vtpi.org/tranben.xls is used for some of these examples, based on a "typical" middle-size city, with a half-million residents who make an average of 24 transit trips annually. This analysis can be adjusted to reflect other conditions and assumptions.

Quantifying Public Transit Benefits *(SECOR Consulting, 2004)*

A study by the Board of Trade of Metropolitan Montreal titled *Public Transit: A Powerful Engine For The Economic Development Of The Metropolitan Montreal Area*, evaluated the benefits of public transit. This document identifies a positive link between public transit, economic development, and quality of life. The study reveals that public transit in metropolitan Montreal generates major economic impacts, including:

- Economic benefits of $937 million.
- Almost 13,000 jobs.
- A 45% return on investment for the provincial and federal governments.

"The economic benefits generated by public transit are not limited to the expenditures of transit authorities in the region. In 2003, for example, public transit enabled Montreal households to save almost $600 million in travel expenses. These savings gave additional purchasing power to the households, which could then spend more on shopping, cultural outings, and recreation. This, in turn, generated double the economic benefits for the Montreal area as spending the same amount on car operating expenses – to the benefit of a host of local merchants and manufacturers," explained Benoit Labonté, president and CEO of the Board of Trade of Metropolitan Montreal.

"Beyond its impact on reducing travel costs, public transit also boosts patronage at business and tourism centres, increases the pool of workers in industrial areas, and facilitates travel to university centres. We should also remember the vital contribution of mass transit to the success of our great sporting and cultural events," concluded Labonté.

Transit Versus Highway Improvements

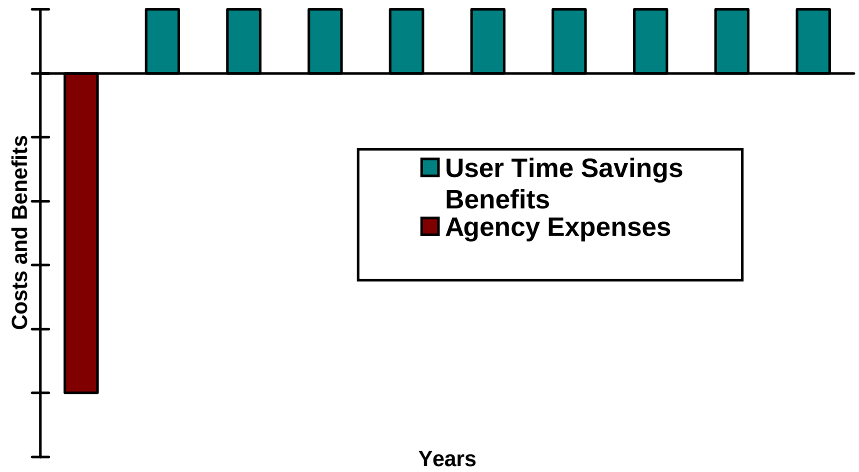
This example illustrates the effects of applying more comprehensive analysis when evaluating possible transportation improvements on a congested corridor. The "Conventional" analysis reflects standard highway evaluation practices which give no consideration to impacts such as parking cost savings and reduced surface street traffic congestion that result when people travel by transit rather than automobile. It also ignores construction traffic delays from the highway project, and the effects of generated traffic. It assumes that travelers saved only about 10¢ per mile when they reduce their vehicle use. It gives no weight to equity benefits from increased transport options for non-drivers, or strategic land use objectives in region land use plans. The conventional analysis concludes that highway capacity expansion is more cost effective than transit improvements. But a more comprehensive analysis shows the transit option actually provides greater net benefits, as illustrated in Table 37.

Table 37 **Conventional and Comprehensive Planning**

Conventional – Only Considers Direct Project Costs	
Light Rail	$300
Highway Expansion	$250
Highway Net Benefits	***$50***
Comprehensive – Considers Additional Costs	
Parking cost savings (3,000 urban parking spaces at $10,000 each)	$30
Surface street traffic congestion (3,000 additional vehicles traveling 6 miles per day, 300 days annually, at 20¢ per mile)	$20
Additional vehicle costs ($500 annual savings per transit user)	$29
Highway construction delays	$2
Generated traffic (reduces highway net benefits)	Probably Substantial
Environmental & social benefits	Probably Substantial
Transit Net Benefits	***$30+***

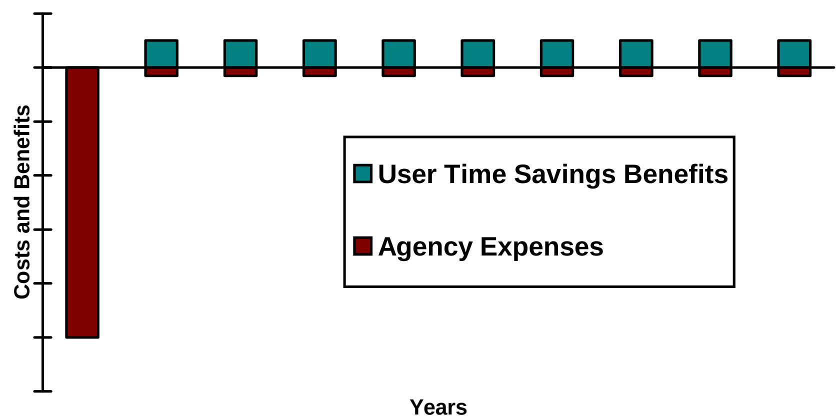
Figures 16 and 17 illustrate lifecycle cost analysis of roadway and transit investments using a conventional analysis. The graphs indicate benefits (bars above the baseline) and costs (bars below the baseline) projected ten years into the future for a highway and rail transit investment.

Figure 16 **Conventional Highway Investment Analysis**



This figure illustrates conventional analysis of highway project costs and benefits. (For simplicity this figure ignores discounting, which would reduce the value of future impacts.)

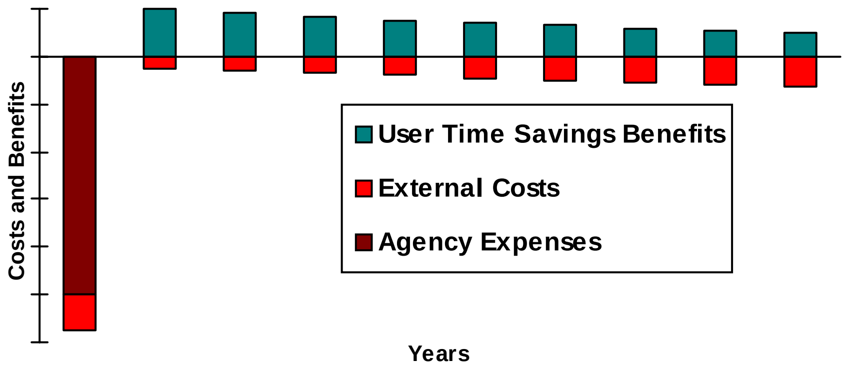
Figure 17 **Conventional Transit Investment Analysis**



Conventional analysis only considers direct financial public agency expenditures as costs, and congestion reduction (primarily user travel time savings) as benefits. This tends to make highway investments appear most cost effective.

More comprehensive investment analysis incorporates several other factors. It takes into account the increased congestion and declining traffic speeds that occur over time due to generated traffic. It incorporates external costs from increased automobile use, such as parking demand, surface street congestion, accidents and pollution. It accounts for transit benefits such as increased travel options for non-drivers and more efficient land use. The conventional analysis ignores many of these impacts, and so tends to skew planning decisions toward automobile-oriented improvements and away from more alternatives that involve alternative modes or management strategies.

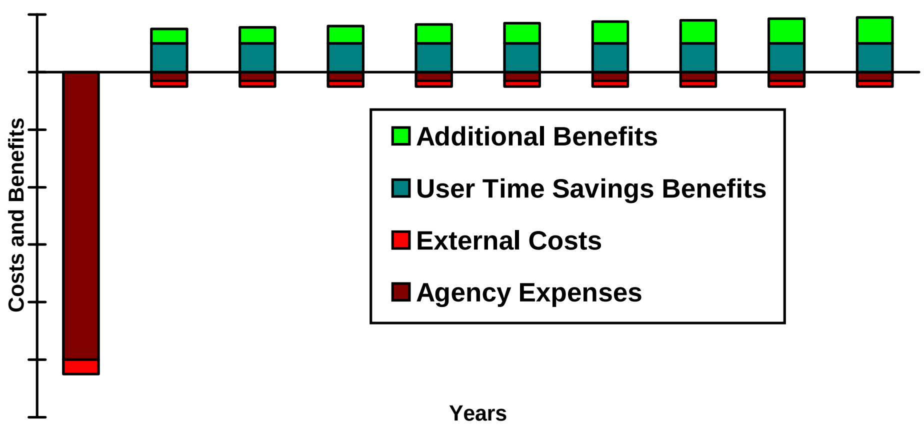
Figure 18 **Comprehensive Highway Investment Analysis**



This figure shows the effects of generated traffic and the external costs of the induced vehicle travel, which reduces the long-term net benefits of highway capacity expansion.

Figures 18 and 19 illustrate more comprehensive analysis of projected benefits and costs, taking into account these additional impacts. This is not to suggest that transit is always more cost effective than highway improvements. However, it shows how more comprehensive analysis can affect planning decisions.

Figure 19 **Comprehensive Transit Investment Analysis**



Comprehensive analysis incorporates the impacts of generated traffic, external costs, and mobility benefits provided by transit. This indicates greater costs for highway investments and greater benefits for transit investments.

More comprehensive analysis can also take into account the potential of increasing transit benefits by applying various support strategies, such as commute trip reduction programs, transit priority, parking and road pricing, transit-oriented land use development polities, and improved marketing. By increasing ridership and operating efficiency, such strategies can make transit more cost effective and competitive.

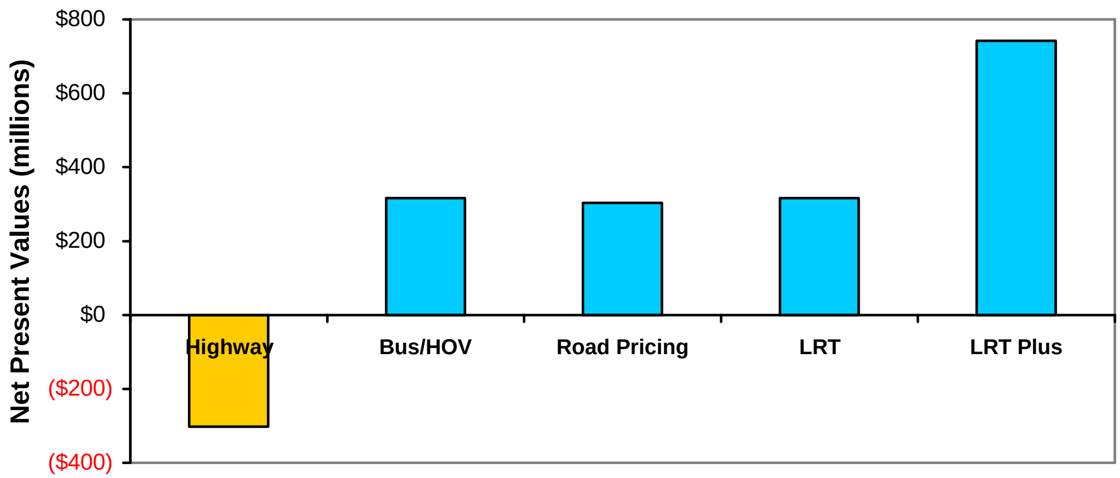
Comparing Mobility Improvements

A study evaluated various options for improving transportation between the city of Victoria and various suburbs called the Western Shore (Litman, 2002). Five transportation options were considered:

- *Highway expansion* - build an additional general purpose travel lane on the main roadways between downtown Victoria and Langford Center.
- *Road pricing (tolls)* - implement variable electronic road tolls to reduce peak-period traffic volumes to optimal levels.
- *High occupancy vehicle lane (HOV)* - build an additional highway lane for buses, carpools and vanpools, plus traffic signal preemption for buses.
- *LRT Basic* - build an 18 kilometer rail system from James Bay to Langford Center, with traffic preemption, as proposed in the ND Lea report (1996).
- *LRT Plus* - build a rail system and implement the Regional Growth Strategy's smart growth policies that further support use of alternative transportation options.

These five options were evaluated using a comprehensive analysis framework that included monetized values of various consumer, economic, social and environmental impacts. The graph below shows the results. Although all five options reduce traffic congestion, their net benefits (total benefits minus total costs) vary due to other impacts. *LRT Plus*, which includes additional features that improve accessibility, increase transit ridership and support regional development objectives, ranks highest because it provides the greatest range of overall benefits. The *Bus/HOV*, *Road Pricing* and basic *LRT* options also provide net benefits. The highway option has negative net value because it increases total vehicle traffic, which increases parking costs, downstream congestion and crashes that more than offset congestion reduction and vehicle costs savings benefits.

Figure 20 **Quantitative Analysis** (20-year Net Present Value)



The quantitative analysis ranks LRT Plus highest, followed by LRT Basic, HOV, road pricing and highway options.

Current Service

This analysis examines the value of current bus and demand response services. Table 38 summarizes the results. Because this is a medium-size city, about half of transit trips are assumed to be made by transit dependent riders, and half are assumed to be discretionary trips that substitute for automobile travel. This analysis indicates that the current transit system imposes net annual costs (costs minus fares) of about $28 million, and benefits of about $58 million, or about $30 million in net annualized benefits. It also provides 773 additional region jobs compared with the same money spent on motor vehicles expenses.

Table 38 **Current Transit Service Benefits**

	Bus	Demand Response	Totals
Total Costs (Sum of all program costs)	$28,627,500	$4,957,088	$33,584,588
Net Costs (Costs minus fare revenues)	-$20,627,500	-$3,957,088	-$24,584,588
Benefits (Sum of benefits)	$50,449,743	$7,404,562	$57,854,305
Net Benefits (Benefits minus project costs.)	$29,822,243	$3,447,474	$33,269,717
Benefit/Cost Ratio	1.8	1.5	1.7
Regional Jobs Created	620	153	773

This only includes impacts suitable for quantification, there are probably additional benefits, such as the equity value from providing opportunity to people who are physically, economically or socially disadvantaged, and economic development benefits due to support for activities such as higher education and tourism. Economic benefits are particularly large from a regional perspective because much of the funding is from external sources.

Rider Incentives

Many transit systems have relatively low load factors. Buses seldom operate full. This unused capacity is an opportunity to increase benefits. Various targeted incentive and promotional programs have proven effective at increasing transit ridership, including UPass programs (bulk purchase of transit passes for college or university students), commute trip reduction programs, parking pricing and parking cash out, fare discounts, park & ride facilities, improved information services, and marketing.

This analysis evaluates the benefits of a new ridership incentive program that increases costs by 10% ($2,000,000), requires 4% additional peak-period bus service (a 1% increase in total bus-miles), and increases ridership by 20% (2.4 million additional annual trips). For this analysis we assume that these programs include a combination of positive and negative incentives (e.g., improved service and increased parking fees), and so user benefits (mobility benefits, option value, reduced chauffeuring costs, and vehicle costs) are calculated at half their total value.

Table 39 **Incremental Benefits From 20% Ridership Increase**

	Current	With Incentives	Difference
Total Costs (Sum of all program costs)	$28,627,500	$30,695,650	$2,068,150
Net Costs (Costs minus fare revenues)	-$20,627,500	-$21,895,650	-$1,268,150
Benefits (Sum of benefits)	$50,449,743	$56,879,052	$6,429,309
Net Benefits (Benefits minus project costs.)	$29,822,243	$34,983,402	$5,161,159
Benefit/Cost Ratio	1.8	1.9	0
Regional Jobs Created	620	682	62

Table 39 summarizes the result, indicating that, in this case, a $2 million incentive program increases benefits by $6.4 million dollars. This analysis illustrates the large potential benefits that can result from incentives that encourage automobile commuters to shift to transit where there is available capacity. Programs such as this are cost effective even if some additional peak-period service must be added due to the large savings that result when urban-peak travel is reduced, reducing congestion, road and parking costs, accident risk and pollution emissions.

New Bus Route

A new bus route is proposed which is projected to cost $500,000 in additional annualized costs, and would to attract about 1,000 daily riders, or 200,000 additional annual trips of which half would substitute for automobile travel. Table 40 shows the estimated benefits by category, totaled over a 15-year period. Mobility benefits (increased mobility by people who are transportation disadvantaged) is the largest single benefit, but efficiency benefits are also significant, including vehicle cost savings, congestion reduction and parking cost savings.

Table 40 **New Bus Transit Route Benefits**

Direct Benefits	Net Present Values
Mobility Benefits	$3,912,864
Option Value Benefits	$167,694
Route Shift Benefits	$1,956,432
Transit Service Quality Improvements	$0
Chauffeur Driver Time Savings	$805,803
Vehicle Operating Costs - Peak	$752,083
Vehicle Operating Costs - Off-peak	$443,192
Congestion - Peak	$470,052
Congestion - Off-Peak	$36,933
Roadway Costs	$167,876
Parking Costs - Peak	$1,107,798
Parking Costs - Off-Peak	$335,388
Crash Costs - Internal	$167,876
Crash Costs - External	$134,301
Pollution	$201,451
Totals	*$10,659,742*

Table 41 summarizes the results over the 15 year period. This indicates that when all monetized impacts are considered, the project costs provide $9.7 million dollars in direct benefits, or $6.1 million in net benefits (benefits minus costs), a 2.7 benefit/cost ratio. It would generate about 209 additional annual jobs, including direct employment of drivers and mechanics, and multiplier effects.

Table 41 **New Bus Transit Route Summary** (15-year Net Present Value)

	Impacts
Total Project Costs	-$5,869,976
Net Costs (Public Subsidy)	-$3,634,053
Project Benefits	$10,659,742
Net Benefits	$7,025,689
Benefit/Cost Ratio	2.9
Regional Jobs	205

New Rail Route

A new rail line is being evaluated which would cost $250,000,000 in construction expenses and $5,000,000 in additional annual operating costs, and would to attract a projected 10,000 daily riders, or 2,200,000 additional annual trips of which almost half would substitute for automobile travel. Table 42 shows the estimated benefits by category, totaled over a 15-year period.

Table 42 **New Rail Transit Route Benefits** (15-year Net Present Value)

Direct Benefits	Net Present Values
Mobility Benefits	$58,692,964
Option Value Benefits	$139,745
Route Shift Benefits	$11,738,593
Transit Service Quality Improvements	$22,359,224
Chauffeur Driver Time Savings	$8,058,032
Vehicle Operating Costs - Peak	$7,520,830
Vehicle Operating Costs - Off-peak	$4,431,918
Congestion - Peak	$4,700,519
Congestion - Off-Peak	$369,326
Roadway Costs	$1,678,757
Parking Costs - Peak	$11,077,979
Parking Costs - Off-Peak	$3,353,884
Crash Costs - Internal	$1,678,757
Crash Costs - External	$1,343,005
Pollution	$2,014,508
Totals	*$139,158,042*

Table 43 summarizes net value analysis. Considering just direct travel impacts the project has a negative net value of -$139 million, and a 0.5 benefit/cost ratio, but when indirect travel impacts are considered, resulting from reductions in per capita vehicle ownership and vehicle mileage, it provides $89 million in net benefits and has a 1.3 benefit/cost ratio. Such projects tend to provide additional economic and social benefits, including improved accessibility and reduced sprawl. It would generate about 2,050 additional annual jobs from direct employment of drivers and mechanics, and multiplier effects.

Table 43 **New Rail Transit Route Summary** (15-year Net Present Value)

	Impacts
Total Project Costs	-$299,802,725
Net Costs (Public Subsidy)	-$277,443,500
Direct Project Benefits	$139,158,042
Direct Net Benefits	-$138,285,458
Direct Benefit/Cost Ratio	0.5
Indirect Project Benefits	$226,949,758
Direct and Indirect Project Benefits	$366,107,800
Direct and Indirect Net Benefits	$88,664,300
Direct and Indirect Benefit/Cost Ratio	1.3
Regional Jobs	2,050

Transit Oriented Development

A transit oriented development is proposed which will house 1,000 residents. It will incur incremental construction costs of $5 million (above standard developing costs), and $500,000 annual additional operating costs for improved walking and cycling facilities and transit shelters, and small increases in transit service operating costs. Comparisons with other similar developments indicates that this can reduce average annual automobile travel from 12,500 to 10,000 vehicle-miles per resident, a total reduction of 2,500,000 annual vehicle-miles, and increase transit ridership by an average of 20 trips annually per resident, or 20,000 additional trips. It will also increase walking, which provides health benefits, although this is not quantified.

Table 44 summarizes the results. Because this improves transportation options for non-drivers (including both walking and transit) it provides a variety of mobility benefits, and by reducing per capita automobile travel it provides efficiency benefits, including vehicle cost savings to residents, and reductions in the congestion costs, parking costs, accident risk and pollution emissions they impose on others. The results are large total potential benefits.

Table 44 **Transit Oriented Development** (15-year Net Present Value)

	Impacts
Capital Investments	$5,000,000
Annual Costs	$500,000
Annual Ridership Increase	20,000
Project Costs (NPV)	-$9,922,392
Net Costs (Net Additional Fares)	-$9,698,799
Direct Project Benefits	$121,983,774
Direct Net Benefits	$112,284,974
Direct Benefit/Cost Ratio	12.6
Indirect Project Benefits	$440,868,927
Direct and Indirect Project Benefits	$562,852,701
Direct and Indirect Net Benefits	$553,153,901
Direct and Indirect Benefit/Cost Ratio	58.0
Regional Jobs Created	720

Quantitative Analysis

Not all benefits are suitable for monetization. These programs can also be evaluated qualitatively, in terms of their ability to support various objectives, as illustrated in Table 45. To apply this methodology in a particular situation, a committee of stakeholders assigns ratings for each option based on their judgment to reflect community values. This approach can help identify strategies that are particularly effective at supporting community values and objectives.

Table 45 **New Transit Qualitative Analysis**

Category	Existing Service	Incentives	New Bus Route	New Rail Route	TOD
Existing Users					
Price Changes	0	4	0	0	0
Service Quality	0	4	3	5	0
Mobility Benefits					
User Benefits	3	4	3	4	3
Public Services	3	1	3	3	3
Equity	3	4	3	3	3
Option Value	3	0	3	4	3
Efficiency Benefits					
Vehicle Costs	3	0	3	3	3
Chauffeuring	3	1	3	3	3
Vehicle Congestion	3	5	3	3	2
Pedestrian Congestion	3	4	3	3	5
Parking Costs	3	5	3	3	3
Safety, Health and Security	3	3	3	3	4
Roadway Costs	0	0	0	3	0
Energy and Emissions	3	3	3	3	3
Travel Time	0	0	0	3	0
Land Use					
Transportation Land	1	3	1	4	4
Land Use Objectives	1	3	1	5	5
Economic Development					
Direct Expenditures	2	0	3	4	1
Consumer Expenditures	2	3	3	4	3
Land Use Efficiencies	1	3	1	5	5
Productivity Gains	2	4	2	4	3
Strategic Development	1	3	1	5	3
Transit Efficiencies	2	3	2	3	3
Totals	*45*	*60*	*50*	*80*	*62*

Conclusions

How transport is evaluated can effect the perceived value of public transit. Different evaluation methods give very different conclusions concerning the value of a particular service or improvement. The selection of evaluation method is not simply a matter of opinion or preference. Comprehensive evaluation is essential for producing accurate results. Some important factors are described below.

- Evaluation that ignores parking and vehicle cost savings that result when consumers shift from driving to transit tends to undervalue transit and favor automobile investments.
- Some methods of measuring traffic congestion (such as roadway level-of-service, travel time index and average traffic speeds) only consider impacts on motorists, ignoring congestion cost reductions to people who shift from automobile to grade-separated transit modes.
- Increased highway capacity tends to increase traffic volumes on surface streets, increasing "downstream" traffic congestion. Shifting travel to transit tends to reduce such impacts.
- Many people find riding quality transit (convenient, comfortable and safe) less stressful than driving in congestion. Evaluation that ignores this factor tends to undervalue transit.
- Some transit improvements increase transit travel speed, convenience and comfort, providing benefits to both existing transit users and those who shift mode in response to these improvements. Evaluation that ignores any of these benefits tends to undervalue transit.
- There are many possible ways to evaluate the value of transit in a community. Analysis that considers the portion of total mobility by transit tends to favor automobile solutions. Marginal impact analysis that considers transit's ability to address specific problems (traffic and parking congestion, mobility for non-drivers) tends to favor transit-oriented solutions.
- There are many possible ways of measuring the transit-dependent population in a community. A narrow perspective only considers residents who live in zero-vehicle household. A more comprehensive perspective considers anybody who uses transit occasionally (such as during the last two months), or who has a frequent transit user in their household.
- Rail transit tends to encourage urban infill and is often a catalyst for more walkable neighborhoods, while urban roadway expansion tends to stimulate sprawl. Evaluation that considers land use planning objectives tends to place a greater value on rail transit. Evaluation that ignores these factors tends to favor highway investments.
- Highway capacity expansion tends to reduce congestion during the short term, but this benefit declines over time, and the resulting generated traffic can increase other costs such as downstream congestion, accidents and pollution emissions. Transit benefits tend to be smaller in the short term, but increase over time. As a result, evaluation that focuses on short-term impacts tends to favor highway expansion, while those that take a longer-term perspective tend to favor transit improvements.
- Transit improvements tend to improve mobility for non-drivers, particularly where transit provides a catalyst for more walkable neighborhoods. As a result, evaluation that considers equity objectives tends to favor transit over highway improvements, particularly comprehensive programs that include transit-oriented development.
- Transit service and ridership tend to increase if transit is implemented with various support strategies. Evaluation that ignores these strategies will tend to undervalue the full potential benefits of a comprehensive transit improvement program.

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Organizations

American Public Transit Association (www.apta.com) provides extensive information on public transit issues.

Association for Commuter Transportation (http://tmi.cob.fsu.edu/act/act.htm) is a non-profit organization supporting TDM programs.

Bus Rapid Transit Website (www.fta.dot.gov/brt) provides information on various strategies to improve bus transit service performance.

Bus Partnership Forum (www.dft.gov.uk/stellent/groups/dft_localtrans/documents/divisionhomepage/032414.hcsp), by the UK Department for Transport, includes extensive information on ways of improving local bus service quality.

Canadian Urban Transit Association (www.cutaactu.on.ca) the voice of the Canadian transit industry, and provides a variety of information and resources.

Center for Urban Transportation Research (http://cutr.eng.usf.edu) provides TDM materials and classes and publishes *TMA Clearinghouse Quarterly.*

Center for Transportation Excellence (www.cfte.org) provide research materials, strategies and other forms of support on the benefits of public transportation.

Commuter Choice Program (www.epa.gov/oms/traq) provides information, materials and incentives for developing employee commute trip reduction programs.

Commuter Check (www.commutercheck.com) works with transit agencies to provide transit vouchers as tax exempt employee benefit.

Economic Development Research Group (www.edrgroup.com) provides information on economic evaluation methods, including studies of the economic impacts of transit projects.

Federal Transit Administration (www.fta.dot.gov) provides a variety of resources for transit planning.

International Union of Public Transport (www.uitp.com) is an international organization that supports public transit.

Schaller Consulting (www.schallerconsult.com) offers various information for transit planning and evaluation.

Transit-Focused Development (www.peak.org/~jbs) provides information on transit oriented community design.