Transportation Demand Management: Concept Overview

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Abstract

This white paper summarizes the research findings of a study by the Innovations Unit of the Washington State Transportation Commission on the topic Transportation Demand Management (TDM). The study was authorized by the Long and Short Term Goals Subcommittee of the Commission in March 1991. This research describes the concept of Transportation Demand Management, including benefits, criticisms, and related government policies. A two-part research process was employed, beginning with a Literature Review and synthesis of recent relevant reports, surveys, books, articles, and legislation, as well as personal interviews. This was followed by an Analysis phase in which the information collected was organized into categories of TDM strategies. Each category includes a definition of concepts as well as illustrative case studies.

This white paper consists of an introduction and five sections. Introductory remarks discuss the significance of TDM and describe relevant Washington state legislation.

Section I introduces parking price strategies, beginning with a discussion of federal policy toward parking pricing. The TDM strategies of reduced parking supply and preferential parking are presented and their effect on parking pricing and reduced single occupancy vehicle (SOV) use is illustrated.

Section II discusses other SOV price disincentives besides parking pricing. These disincentives include fuel pricing in the form of a direct gasoline tax or carbon tax, and congestion pricing.

Section III discusses strategies that encourage high-occupancy vehicle (HOV) modes. The components of a ridesharing program are described and the importance of preferential treatment of high occupancy vehicles is illustrated.

Section IV discusses strategies that eliminate or modify commute trips. Case studies illustrate the benefits and criticisms of telecommuting and compressed work weeks and their ability to reduce trips. Flextime or flexible work hour strategies are also described in this section.

Section V discusses alternatives to the automobile, including transit, walking, and bicycling. Facilities and strategies that the public and private sectors can implement to encourage these alternate modes are illustrated.

Related Reports

This white paper is a summary of current literature on Transportation Demand Management. A companion document containing case studies of TDM programs implemented by moderate size employers will also be published, as well as an illustrated presentation of TDM strategies.

Acknowledgments

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Introduction

Transportation demand management (TDM) encompasses any strategy aimed at reducing roadway demand, as measured by a reduction in the number of single occupancy vehicles (SOVs), a reduction in vehicle miles traveled (VMT), an increase in average vehicle occupancy (AVO), or an increase in alternate mode usage (AMU). The TDM strategies discussed in this document include parking charges, parking taxes, fuel pricing, congestion pricing, preferential carpool parking, telecommuting, compressed work weeks, flextime, and strategies that promote high occupancy vehicles (HOVs), or alternate modes such as walking and bicycling.

TDM strategies are often used in conjunction with transportation system management (TSM). TSM can be broadly defined as any strategy that improves the efficiency of the transportation system. In contrast to demand-oriented TDM approaches, TSM techniques increase the effective transportation supply or capacity. TSM strategies include traffic signal synchronization, designation of left-turn lanes, and ramp metering. The line separating TSM and TDM can become blurred; for instance, ramp metering coupled with an HOV bypass lane may increase the demand for ridesharing as well as increasing the highway capacity. In this document, some TSM strategies are mentioned because they can be considered TDM strategies, or because they enhance the effectiveness of a TDM strategy.

WHY TDM IS NECESSARY

Although TDM techniques can offer the benefits of decreased congestion and energy consumption, the primary reason for making TDM a central component of Washington state's transportation policy is the increasing problem of air pollution. Air quality is a significant issue in Washington state. In some areas, levels of carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC) exceed federal standards. The Puget Sound Air Pollution Control Agency (PSAPCA) and the Department of Ecology (DOE) have estimated the following automobile emissions for King, Pierce, and Snohomish counties:

- 3,401,606 pounds of CO per day (77 percent of total daily CO pollutants)
- 492,172 pounds of NOx per day (60 percent of total daily NOx pollutants)
- 550,880 pounds of VOC per day (45 percent of total daily VOC) (Anderson 1992).

Smog (ozone), caused by a reaction of NOx and VOC with sunlight, is an increasing problem in urban areas. Smog can cause shortness of breath, coughing, and irritation of the eyes, nose, throat, and respiratory system. The Air Resources Board of California found that air pollution may be a contributing factor to the heart and lung diseases that result in some 80,000 deaths per year in California (Lopez-Aqueres, Siwek and Peddada 1991, 4).

Many TDM strategies are aimed at reducing traffic during peak hours, when congestion results in slower vehicle speeds. This is particularly important because the relationship between most automobile emissions and speed is inverse. Figures 1 and 2 show that the highest per-mile carbon monoxide and nitrogen oxide emissions occur at vehicle speeds of less than 15 miles per hour (California Air Resources Board 1992).

Transportation Trends

The data in Table 1, taken from the federal census, reveal a substantial increase in the percentage of people who are traveling to work in single occupancy vehicles. At the same time, the census indicates that the percentage of commuters who are walking, working at home, or using high occupancy modes, is declining. The average commute time has also increased slightly. These trends may be attributed to lower gas prices, more energy-efficient automobiles, continued corporate and residential movement to suburbs, and an increase in the number of two-career couples (Harney and Little 1992, 7A).

Washington state experienced a population increase of 12.5 percent between 1980 and 1988. The Puget Sound Council of Governments (now called the Puget Sound Regional Council) estimates that the population will double in the Puget Sound area from 1990 to 2020, and that employment will increase by an average of 31,000 jobs per year. Population growth, coupled with an increase in vehicle miles traveled, has contributed to the air pollution that now constitutes a significant threat to the quality of life in Washington state (Planning, Research, and Public Transportation Division 1991a, 2).

Urban highways are already at capacity; building additional highways to accommodate projected growth would not, in many cases, be effective. The Washington State Department of Transportation (WSDOT) has stated that "Resources may not exist to embark upon major road building efforts. The costs of simply maintaining existing facilities have increased

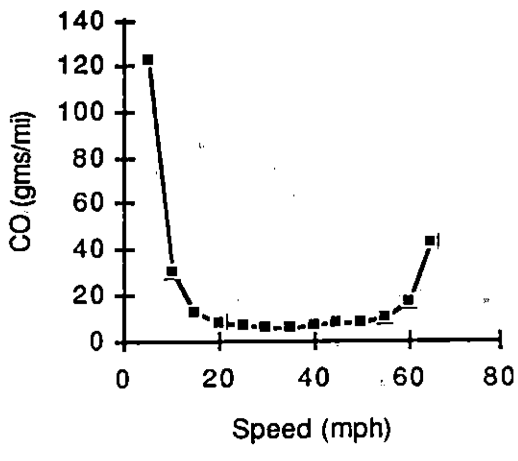


Figure 1. CO emissions

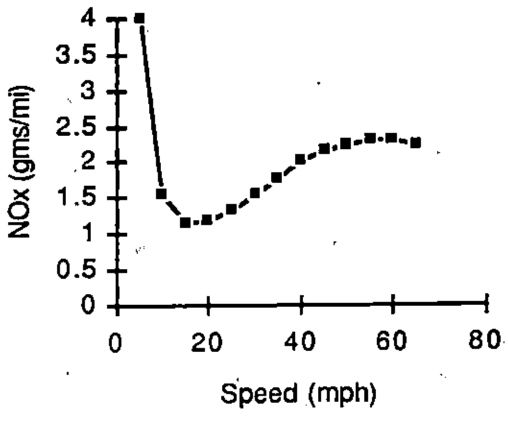


Figure 2. NOx emissions

Table 1. Census data

	1980	1990
Driving to work alone	64.4%	73.2%
Carpooling to work	19.7%	13.4%
Walking to work/working at home	7.9%	6.9%
Riding public transportation to work	6.4%	5.3%
Average commute time	21.7 minutes	22.4 minutes

(Harney and Little 1992, 7A)

to the point that new construction is restricted" ((Planning, Research, and Public Transportation Division 1991a, 2).

TDM Benefits

A TDM program can reduce emissions by increasing average vehicle occupancy, decreasing the number of vehicle trips taken (thus decreasing vehicle miles traveled), and reducing congestion.

TDM benefits can be difficult to quantify. The city of San Diego, California, conducted a study to determine the effect of its Employment Trip Reduction Ordinance on vehicle emissions. The ordinance required affected employers to achieve an average vehicle occupancy of at least 1.5 for all employees arriving at the work site during a 24-hour period. Using 1987 as the base year, transportation planners in San Diego modeled local travel behavior and emission data. Based on the model's results, San Diego anticipates the following reductions by the year 2000:

- an 8 percent reduction in VMT,
- a 6.6 percent reduction in the number of trips,
- a 1.9 percent reduction in VOC (5.2 tons per day),
- a 2 percent reduction in NOx (5.7 tons per day), and
- a 4.8 percent reduction in CO (68 tons per day) (San Diego Association of Governments 1991, 17-18, 93).

Organizations that presently subsidize their employees' parking costs can save substantially if their employees switch to alternative transportation modes such as public transit and carpooling. According to a study conducted in 1987 and cited by Lopez-Aqueres, Siwek and Peddada (1991), employers in Los Angeles County spend between $1.3 and $1.7 billion per year on employee parking. Lopez-Aqueres et al. also found that an effective TDM program "...may increase labor productivity by reducing absenteeism, tardiness, and stress stemming from the frustration and aggravation of having to drive in heavy traffic." Benefits to employees include savings on parking charges, gasoline expenditures, and automobile wear and tear. A recent survey of commuters concluded that savings on parking costs were perceived as the major carpooling benefit (Lopez-Aqueres et al. 1991, 4).

Criticisms of TDM

Not everybody believes that TDM offers a solution to our transportation problems. To date, TDM has dealt mostly with reduction of commute trips, which make up only 30 percent of all trips (Pisarski 1991, 3). The Puget Sound Regional Council estimates that active regional TSM and TDM programs could reduce pollution by 10 percent (Planning, Research and Public Transportation Division 1991a, 2). While these programs may help the region to meet current federal clean air standards, they may not be strong enough to counteract population growth, increasing vehicle miles traveled, and low average vehicle occupancy, the major factors in congestion and air pollution.

When implemented in isolation, the impact of some TDM strategies is limited. In Pleasanton, California, for example, a trip reduction ordinance (TRO) was adopted in 1984. This TRO has resulted in a peak-hour traffic volume reduction of more than 45 percent through the use of an alternative work hours strategy. While this TRO was effective in serving the immediate goal of reducing congestion, the SOV rate has remained at 85 percent since 1986 (Ferguson and Sanford 1990, 5-6). SOV use there remains high primarily because the incentives to use alternate modes are few. Parking is plentiful and free, while employer subsidies toward the high cost of transit and ridesharing are nonexistent. Employees who do not wish to drive alone must make their own arrangements, often without any formal incentives from their employers.

Many TDM strategies are designed to expose individuals to alternate modes of transportation modes. The hope is that once a person has ridden the bus or participated in a carpool, he or she will continue to do so. Unfortunately, this is not always be the case; for example, the 1989 San Francisco earthquake caused the temporary closure of some critical highway segments, notably the San Francisco Bay Bridge. Many commuters switched to alternate modes, such as the Bay Area Rapid Transit (BART) rail system, to adapt to the emergency. However, once the bridge reopened, people returned to their normal commuting patterns, and BART ridership dropped back to pre-earthquake levels (Giuliano 1992, 332).

COMMUTE TRIP REDUCTION LAW

The Commute Trip Reduction (CTR) Law, passed in 1991, represents an effort on the part of Washington state to reduce congestion and air pollution. Municipalities in California, Arizona, Maryland, and New Jersey have either implemented, or will soon implement, TDM/TSM policies similar to Washington's.

The Commute Trip Reduction Law requires that major employers in Clark, King, Kitsap, Pierce, Snohomish, Spokane, Thurston, and Yakima counties develop a TDM policy to reduce single occupancy vehicle (SOV) use and vehicle miles traveled (VMT).

Major employers include those public or private organizations with 100 or more employees who arrive at work between 6:00 a.m. and 9:00 a.m., and who have been employed for at least one year (CTR Task Force 1992). In air quality non-attainment areas, employers with as few as ten employees may be required to implement TDM programs after 1996. After the Commute Trip Reduction Law was passed, a CTR Task Force was appointed to help implement the law. This task force will also determine the need for lowering the employee threshold based on progress achieved by major employers (CTR Task Force 1992, v).

Employer Requirements

Under the CTR law, the employer must designate an employee transportation coordinator (ETC) to oversee all elements of the employer's CTR program, and to act as a liaison between the employer and the local government. It is not required that the ETC be a full-time employee, and the responsibility may be assigned to an employee who is already in place (CTR Task Force 1992, 1-13).

Each employer is required to distribute information pertaining to SOV alternatives to employees at least once a year. The employer must also submit annual reports to the CTR Task Force that include a review of the organization's progress toward SOV/VMT reduction on the part of its employees, and a plan for maintaining or improving its progress (CTR Task Force 1992, 1-14).

Dates of Compliance

The following dates of compliance were specified in the summary of the commute trip reduction draft guidelines. While many of the dates listed below were explicitly stated in the CTR law, others were extrapolated from the law's timeline.

June 1991	Task Force issues guidelines.
January 1992	Cities and counties adopt ordinances.
February 1993	Cities and counties notify employers.
April 1993	Employers submit applications for credit for TDM strategies already in place.
July 1993	Cities and counties submit programs; employers submit programs; and employers identify themselves as an affected employer, if not already notified.
January 1994	Cities, counties, and employers implement programs.
July 1994	Cities and counties report to task force; employers submit annual reports.

1995 - 15 PERCENT REDUCTION GOAL

July 1995	Cities and counties report to task force; employers submit annual reports, including survey results.
December 1995	Task force reports to legislature.
July 1996	Cities and counties report to task force, employers submit annual reports.

1997 - 25 PERCENT REDUCTION GOAL

July 1997	Cities and counties report to task force; employers submit annual reports, including survey results.
July 1998	Cities and counties report to task force; employers submit annual reports.

1999 - 35 PERCENT REDUCTION GOAL

July 1999	Cities and counties report to task force; employers submit annual reports, including survey results.
December 1999	Task force reports to legislature.
July 2000	Cities and counties report to task force; employers submit annual reports (CTR Task Force 1992, 8).

GROWTH MANAGEMENT ACT

Increasing development, congestion, and threats to the environment all contributed to the passage of Washington state's Growth Management Act (GMA) in 1991. The GMA mandates that counties with populations of over 50,000, or those that have experienced growth of more than 10 percent over the past ten years, must create a comprehensive plan to facilitate and direct growth (RCW36.70A, 6).

GMA Requirements

- Cities and counties were to submit county-wide planning policies by July 1, 1991. Policies are to include a framework for the comprehensive plan, and must address urban growth areas, urban service provisions, and public facilities siting. Each comprehensive plan is to include sections on transportation, affordable housing, economic development, and fiscal impacts of the comprehensive plan.

- Natural resource lands and environmentally sensitive areas must be given protection by September 1, 1991.

- Comprehensive plans are to be submitted by July 1, 1993 and must contain the following elements:

  - land use,
  - housing,
  - utilities,
  - transportation,
  - capital facilities, and
  - rural.

- All cities must bring their development regulations into line with their comprehensive plans by July 1994.

- Once urban growth boundaries have been established, no annexation can take place outside the boundary.

- Coordinated planning among jurisdictions is required.

- Collective identification of lands that are potentially valuable for public use by city, county, and neighboring jurisdictions, is required (RCW36.70A, 8-16).

As of August 1992, ten out of 26 counties had submitted their county-wide planning policies; 15 counties had submitted their policies for the protection of resource areas; and 11 had submitted their policies for the protection of critical areas. Approximately the same percentage of cities had submitted their planning and protection policies. The rest of the affected counties and cities will submit their planning and protection policies by the end of the year (Mayjack 1992).

STATE CLEAN AIR AMENDMENTS

According to the Washington state Clean Air Act Amendments (1991), "Over three million residents of Washington state live in areas where air pollution levels are considered unhealthful. Of all toxic chemicals released into the environment, more than half enter our breathing air. Citizens of Washington state spend hundreds of millions of dollars annually to offset health, environmental, and material damage caused by air pollution" (RCW 79.94, 2).

WSCAA Requirements

The Washington State Clean Air Amendments require that areas with poor air quality re-establish acceptable levels by December 31, 1995. Some areas of Washington state do not meet federal air quality standards for ozone, carbon monoxide (CO), and particulate matter (PM10). The areas in non-attainment for at least one of the pollutants include the region extending from Tacoma to Everett and east past Lake Sammamish; Vancouver, Thurston County, Yakima, Spokane, and Wallula (Lee 1992).

The amendments mandate that areas in the state with acceptable air quality must limit air contaminant levels to protect human health and the environment. Cities and counties are encouraged to support strategies that lessen the negative impacts of any facility on all environmental media, including air, water and land (RCW 79.94, 3).

Automobile Emissions

The amendments state that automobile emissions are a major contributor to air pollution, and that they will comprise an increasing proportion of that pollution as the region grows. In accordance with the WSCAA, air quality goals are to be incorporated into the missions and actions of all state agencies. In addition, the Department of Ecology shall do the following:

- Conduct a public education program focusing on the effects of automobile emissions on air quality and public health. Such programs are expected to provide information on emission control devices and on the effect of proper vehicle maintenance on fuel economy and emissions control.

- Notify the public of geographic areas that are in non-attainment, and explain the requirements imposed by this amendment on such areas (RCW79.94, 5 and 8-9).

The rest of the amendments contain guidelines for reducing individual automobile emissions and for reducing air pollutants from industry, outdoor burning, and indoor stoves.

TDM CONCEPT OVERVIEW

The remaining sections summarize TDM strategies for modifying travel demand. Case studies from the U.S., Europe, and Asia illustrate the strategies' effectiveness.

The strategies are organized into five categories:

1. parking pricing strategies,
2. automobile pricing strategies,
3. HOV mode strategies,
4. trip elimination/modification strategies, and
5. alternatives to the automobile.

The section on parking pricing strategies is introduced with a discussion of federal policy toward parking. The principle of using parking pricing as a TDM strategy is presented, and its effects are illustrated with case studies from California and Washington. Other parking strategies that complement TDM objectives, including parking taxes, parking supply reduction, and preferential parking, are also addressed.

The section on automobile pricing strategies discusses fuel pricing and congestion pricing. Fuel pricing is discussed in the form of either an increased gasoline tax or a carbon tax. The concept of congestion pricing is then described and implementation possibilities such as toll systems and advanced automation are explored. Case studies from Singapore and Hong Kong illustrate the use of congestion pricing as a TDM strategy.

The section on HOV mode strategies includes ridesharing programs and preferential treatment of HOVs. The ridesharing discussion includes ridematching, the use of cash incentives, as illustrated by a case study in California, and guaranteed-ride-home programs, as illustrated by a Washington state study. This section also discusses vanpools, the role of employee transportation coordinators, and the marketing and promotion of alternate transportation modes. Preferential treatment of HOVs through the use of HOV lanes and related facilities is discussed and illustrated by means of case studies from California and Texas.

The section on trip elimination and modification strategies includes a discussion of telecommuting, compressed work week, and flextime programs. Telecommuting and telework centers are described in a case study from Hawaii. A case study from California illustrates the effects of a compressed work week program.

The final section, which deals with alternatives to the automobile, addresses transit, walking, and bicycling. Strategies for increasing transit demand are described via a case study from the state of Washington, while case studies that shed light on factors that increase bicycle usage are drawn from California.§

I. Parking Pricing Strategies

Parking pricing strategies are designed to create significant monetary disincentives that will have the effect of decreasing SOV use and encouraging HOV use. Parking pricing disincentives can be combined with complementary incentives; one example of such a strategy is a parking charge, which can be accompanied by a reduction in the available parking supply and discounted, preferential HOV parking. Parking pricing strategies can be effective in negating the effects of free or subsidized parking on SOV use.

In urban work sites throughout the nation, employers commonly offer their employees free or subsidized parking, as shown in studies cited by Shoup and Willson:

- The 1980 National Personal Transportation Study indicated that 93 percent of auto commuters park for free.
- A 1988 survey of four California counties found that 91 percent of automobile commuters park for free.
- A 1989 survey of large standard metropolitan statistical areas (SMSAs) revealed that 90 percent of those who drive to work park for free (Shoup and Willson 1990, 1).

These studies note that employer-paid parking provides employees with a powerful incentive to drive to work alone and works against costly public policies, such as transit subsidies, that are designed to reduce traffic congestion, energy consumption, and air pollution (Shoup and Willson 1990, 1).

Parking costs play an important role in determining whether a person chooses to drive alone or to use some other means of transportation. In fact, free parking provides a more powerful incentive to drive alone than does inexpensive gasoline. Willson and Shoup (1991) found that the average round-trip commute to downtown Los Angeles for those who park for free is 36 miles. Assuming that gas consumption averages 20 miles per gallon, and that gasoline costs $1.50 per gallon, Willson and Shoup estimated that the gas cost for the average round-trip commute is $2.70. In contrast, the average daily cost for monthly parking in downtown Los Angeles is $4.32 (1986 dollars), which is far more expensive than the cost of gasoline (Shoup and Willson 1990, 1).

FEDERAL POLICY

The link between parking pricing and mode choice is affected in part by policy. In 1990, Don Pickrell prepared a paper entitled "Federal Tax Policy and Employer-Subsidized Parking," for the Commuter Parking Symposium, held in Seattle. Pickrell explained that the federal government's rationale for exempting parking fees from income taxation is to encourage employers to provide desirable working conditions, thus increasing employment and productivity (Pickrell 1990, 4). However, this policy also significantly affects an employee's mode choice, insofar as free parking makes driving more convenient and affordable. The employer's offer of a free parking space has a greater value to the employee than would a salary increase sufficient to purchase that same space, because the employee pays no tax on an employer-provided parking space. This tax savings rises in direct proportion to the employee's marginal federal income tax bracket. Thus, employers can make most of their employees better off by offering them free, or below-market-price parking, rather than paying employees higher salaries, which are taxable (Pickrell 1990, 4).

Employer benefits that encourage transit use are taxed in a different way. Under the 1984 Tax Reform Act, employer-provided transit subsidies worth up to $15 per month (recently amended to $21) may be excluded from an employee's taxable income. However, if the value of the subsidy exceeds $21 per month, then the entire amount is treated as taxable income. Contrast this tax exemption with the one governing parking spaces. The best available estimate places the value of a free parking space, which is currently tax exempt, at an average of $58 per month in U.S. cities. The free parking space is equivalent to an increase in yearly taxable income of approximately three times the maximum value of a free transit pass ($696 compared to $252). The federal government's limits on the tax exemption for transit subsidies, but not for parking spaces, promotes driving alone over transit (Pickrell 1990, 2).

If the federal government were instead to tax each employee for his or her parking space at the rate of $58 per month, the per-capita average increase in annual tax liability would come to $167. If three-quarters of the more than 28 million commuters working in central cities with populations of over 500,000 paid taxes on their free parking, then the federal government would receive an additional $4.67 billion per year (Pickrell 1990, 2 and 5).

Possible Policy Changes

One potential policy change that would reinforce parking pricing strategies to decrease SOV use would be to amend the federal tax code to ensure the following conditions:

- Free or below-market-price parking spaces would constitute a taxable fringe benefit. This would eliminate an employer's primary motivation for providing free or subsidized parking (Pickrell 1990, 5).
- Employers could designate some limited portion of each employee's gross earnings as a tax-exempt travel allowance. The ability to do so would be tied to the condition that the employer not offer free parking (Pickrell 1990, 6).

Many feel that the current federal parking tax policy nullifies other federal policies that actually do promote alternative transportation modes, and that policies at the national level generally do not address the behavioral link between convenient free parking and the decision to drive to work alone (Pickrell 1990, 4).

PARKING PRICING

Without some kind of financial disincentive, people will tend to opt for the automobile's convenience. One such disincentive, increasing the cost of parking, appears to be an effective way of discouraging SOV use. In Silver Spring, Maryland, for example, the county owns 80 percent of the parking within the city, and charges SOVs $65.00 per month for parking while HOV parking fees are discounted according to vehicle occupancy. Without any other significant TDM strategy, the city achieved an SOV mode split of approximately 55 percent in 1991 (Silver

Spring Transportation System Management District 1991, 1).

Case Study: Shoup and Willson

In their paper, "Employer-Paid Parking: The Problem and Proposed Solutions," Donald C. Shoup and Richard W. Willson (1990) analyzed the effect of employer-paid parking on mode choice and parking demand. Shoup and Willson reviewed five well-documented case studies that reveal how employer-paid parking subsidies affect travel behavior. The case studies either examined the commuting behavior of an employee group before and after the elimination of employer-paid parking, or compared the commuting behavior of matched samples of employees with and without employer-paid parking.

Table 2 summarizes the results of Shoup and Willson's study. They concluded that eliminating employer-paid parking reduces the solo-driver mode share by an average of 41 percent. The smallest reduction among the cases was 18 percent, and the largest reduction was 81 percent. Unfortunately, the study did not account for the large differences in reduction. Shoup and Willson also looked at the reduction in the number of vehicles, which averaged 27 percent. The 14 percent difference between the SOV reduction and reduction in the number of vehicles was attributed to increased carpooling (Shoup and Willson 1990, 3).

These five case studies, as well as eight examples from another national study (COMSIS 1990) are depicted in Figure 3 along with each company's parking costs. For those case studies where before SOV mode split data are not available, the after SOV mode split is compared to the city or county's average SOV mode split. The figure shows that although higher parking costs usually accompany lower SOV mode splits, there are some deviations from that pattern, which suggests that SOV mode splits cannot be explained by parking costs alone. Other explanations may include parking supply, the availability of alternate modes of transportation, and other employer incentives.

Case Study: U.S. West Communications

U.S. West Communications is located in downtown Bellevue, Washington. In 1981, developers of the company's new Bellevue office opted for the minimum employee parking capacity, which was below the city's minimum requirements. Only 408 parking spaces were provided for the organization's 1,150 employees (COMSIS 1990, 82-84).

Table 2. Parking pricing program results

	SOV Before	SOV After	SOV Reduction	Auto Reduction *
Mid Wilshire (L.A.)	42%	8%	-81%	-38%
Warner Center (L.A.)	90%	46%	-49%	-30%
Century City (L.A.)	92%	75%	-18%	-15%
Civic Center (L.A.)	72%	40%	-44%	-36%
Downtown Ottawa (Canada)	35%	28%	-20%	-18%
AVERAGE	66%	39%	-41%	-27%

* Autos driven per 100 employees

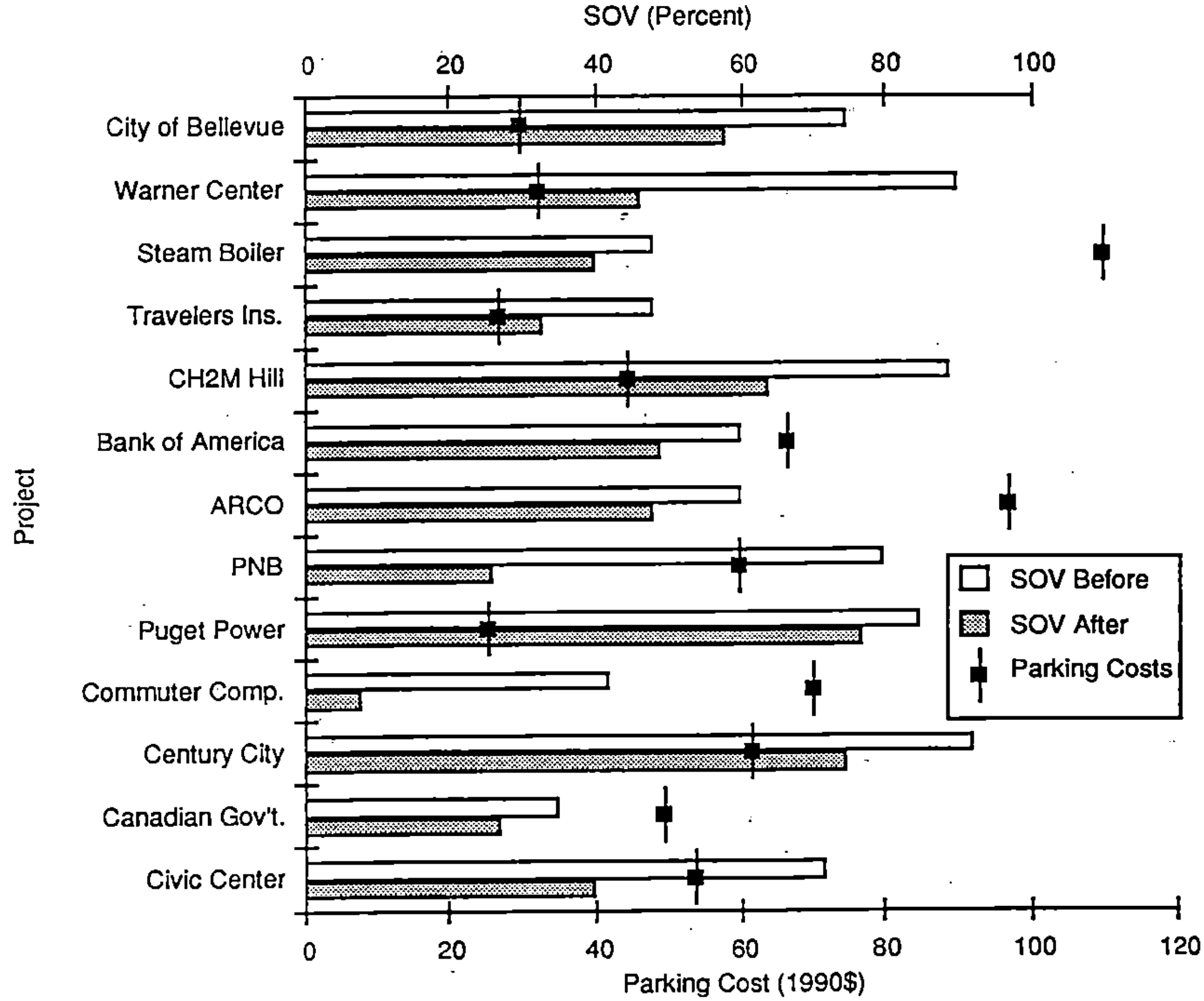
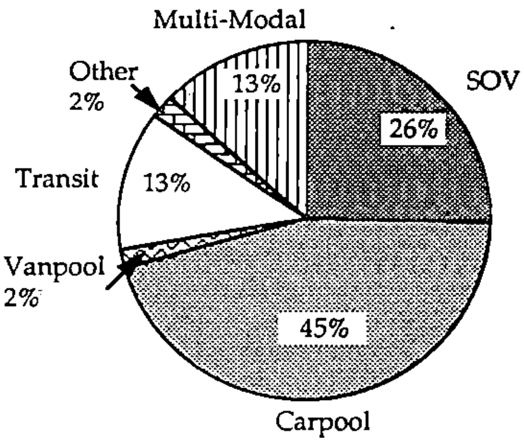


Figure 3. Mode split and parking costs

U.S. West Communications' TDM strategy included the following components:

- a $60 per month parking fee for SOVs,
- a $45 per month parking fee for 2-person carpools,
- free parking for 3+ carpools,
- reduced parking supply,
- flexible work hours, and
- a full time employee transportation coordinator (ETC).

The transportation mode split obtained at U.S. West Communications in 1988 was as follows:



U.S. West Communications mode split after implementation

* The carpool category included carpools formed at a nearby park-and-ride lot. The multi-modal category included employees who drove to a park-and-ride lot, then took some form of HOV to work.

This case is significant because of the low SOV mode split, even factoring in the employees with a multi-modal commute. The parking supply reduction and the high parking charge discourage SOV use; carpools, facilitated by the ETC, are encouraged by the HOV discount.

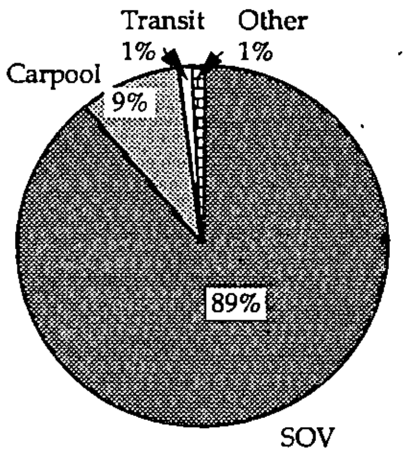
__Case Study: CH_2M Hill__

The Bellevue branch of CH_2M Hill, a national consulting firm, employs approximately 400 people. When the organization relocated to Security Pacific Plaza in downtown Bellevue in 1987, it implemented a TDM program because the office site only had 325 parking spaces. Furthermore, CH_2M Hill planned to reduce parking to 210 spaces within four years, and to reduce parking even further within eight years (COMSIS 1990, 86-87).

The CH_2M Hill TDM strategy included the following components:

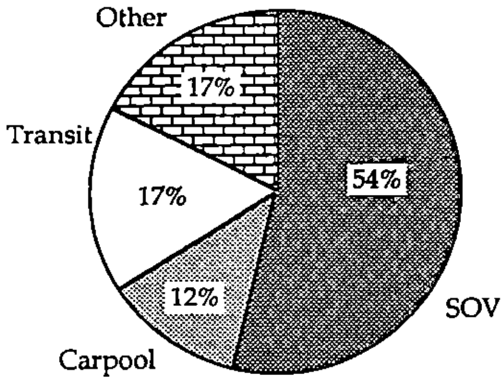
- a $40 per month parking fee for SOVs,
- a $40 per month travel allowance for all employees, which they may spend on parking or on alternative modes of transportation,
- a $15 per month subsidy for transit users, and
- free carpool parking.

In December 1986, before the TDM program was implemented, CH_2M Hill's transportation mode split was as follows:



CH_2M Hill mode split before implementation

The transportation mode split in January 1988, after TDM implementation, was as follows:



CH_2M Hill mode split after implementation

A significant feature of CH_2M Hill's program is its use of a travel allowance, which was set to equal the parking fee. While this move placated those employees who still wished to drive alone, many employees elected not to spend their travel allowance on parking. The decision not to purchase a parking space indicates that many employees attach a lower value to parking than its current market price.

PARKING TAXES

Several major cities have imposed parking taxes, including Baltimore, Chicago, Los Angeles, New York, Pittsburgh, San Francisco, and Washington D. C. In each of these areas, the policy has been similar: a percentage or flat rate has been added to the regular parking fees that are collected by the operator. These taxes apply to all paid parking, and go to the cities' general funds (Ulberg 1990, 1).

Parking Tax and TDM

Parking taxes are generally used as a local funding mechanism. Parking taxes in the areas just described go into a general fund, and can therefore be used for a variety of needs. If the revenue is used for transportation purposes, however, it may inadvertently be used to provide greater street and highway capacity, thereby defeating the purpose of any TDM measures that may be in place. One way to ensure that a parking tax policy is consistent with a TDM strategy is to control the use of the tax revenue. For example, if the revenues are instead "...allocated to transportation demand management measures, such as transit subsidies or ridesharing programs, the tax can provide consistent impetus for mode shift from single occupancy vehicles" (Ulberg 1990, 2).

A recent King County study estimated that a daily tax of $0.50 for all off-street parking would generate revenues of almost $100 million per year. The study considered all possible off-street spaces, excluding residential parking, and projected the tax revenue based on the number of employees in King County and on the known transportation mode split. If the parking tax revenues were then spent to enhance non-SOV transportation modes, such taxation would be compatible with a TDM strategy. In addition, a parking tax can, by itself, constitute a TDM strategy if it is applied to a broad range of parkers, and if it is high enough to change the travel behavior of those who commute alone (Ulberg 1990, 1-2).

PARKING SUPPLY REDUCTION

Parking charge strategies are difficult to implement successfully in areas where free parking is plentiful. Conversely, it is much easier to impose parking charges in urban centers and other areas where parking spaces are in short supply. As a result, limits on the parking supply are often implemented in conjunction with a parking charge strategy.

Case Study: Portland

The city of Portland, Oregon, has managed its parking supply by capping the total number of downtown parking spaces. The 1975 Downtown Parking and Circulation Policy (DPCP), the transportation element of the city's downtown plan, is the center of this strategy. The DPCP limits the maximum number of parking spaces in a new development; limits are based on square footage and on the type of development. This approach runs contrary to the typical building requirement that developers must provide some minimum number of parking spaces.

Portland's approach to parking management has been effective. Table 3 shows an increased number of downtown employees and an increased number of downtown transit trips, with no change in the number of parking spaces. During this period, automobile trips have only increased at the rate of only about one percent per year (Coleman 1990, iv, 13-14).

PREFERENTIAL PARKING/ HOV PARKING DISCOUNT

Preferential parking for carpools and vanpools encourages HOV use, especially if the parking supply is tight, or if the SOV parking fee is high. For regional effectiveness, preferential parking should be implemented in conjunction with TDM strategies that increase parking fees. Also, changes in local parking codes to allocate preferential parking should be implemented in all travel markets, including commercial, educational, institutional, employment, and recreational (Ekistic Mobility Consultants 1990, 37-38).

Many employers in Puget Sound already provide preferential parking spaces to employees who rideshare. Preferential parking strategies are also supported by the proposed Transportation Policy Plan for Washington State (Transportation Planning Office 1992), which places a higher priority on HOV facilities than on SOV facilities.

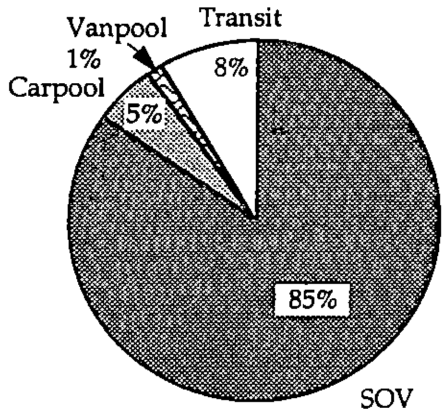
Table 3. Parking supply reductions in Portland

	1975	1989
Employees	69,800	90,000
One-way transit trips downtown/day	79,000	128,000
Parking Spaces	40,000	40,000

In Seattle, for example, on-street HOV parking permits cost $75.00 for three months; this is dramatically lower than comparable lot parking costs for SOVs of $120 to $200 a month. As of August 1992, 524 HOV permits had been issued. Spaces are not individually assigned, but there are approximately 300 spaces that are permanently reserved for carpools. Remaining on-street spaces open up to SOVs after 9:00 a.m. or 10:00 a.m. Carpool parking spaces are at 75 percent capacity (Brown 1992).

Case Study: Puget Power

Puget Power, a public utility headquartered in Bellevue, Washington, implemented a TDM program upon consolidation of its 830-person employment base to a downtown Bellevue site with only 650 parking spaces. The program's primary strategy was a $21.00 parking charge, and resulted in the following mode split: (COMSIS 1990, 83-86).

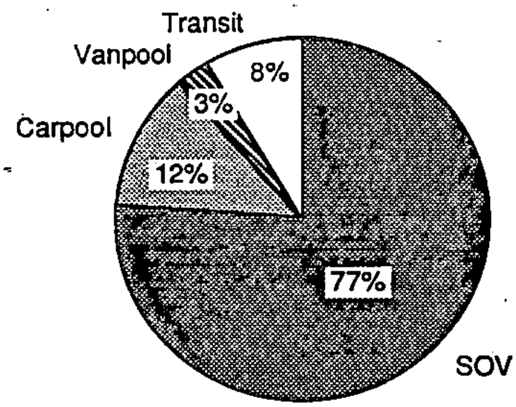


Puget Power mode split after implementation

In 1989, Puget Power faced the loss of an additional 110 parking spaces due to the termination of a lease. This change necessitated further TDM measures; the program changes consisted of the following:

- Carpoolers could park for free (the parking fee had previously been $21 per month).
- Carpoolers were offered reserved, preferential spaces.
- Carpoolers and transit users could park as SOVs two days per month for free.
- The transit subsidy was raised $3.00, to a total of $15.00.
- New HOV users were given $35.00 certificates after three months; current HOV users were given $15.00 certificates.

One month after implementing the TDM changes, Puget Power's mode split had shifted, as follows:



Puget Power mode split after additional implementation

The most significant change in Puget Power's TDM program was the provision of free, reserved parking for HOVs. The significance of this change is reflected in the doubled carpool and vanpool ridership.§

II. Automobile Pricing Strategies

Automobile pricing strategies entail monetary disincentives (besides parking pricing) that encourage drivers to travel at off-peak times, to reduce the number of trips made, or to shift to other transportation modes. Automobile pricing strategies include fuel pricing and congestion pricing (e.g., charging a toll based on the level of congestion). While the U.S. does not offer any examples of successful pricing strategies of these types, other industrialized nations have reduced both congestion and air pollution, through fuel and/or congestion pricing.

FUEL PRICING

Fuel pricing involves raising the cost of gasoline to a level high enough to discourage excessive driving or to encourage shared travel. In the absence of a significant monetary incentive or disincentive, it is difficult to encourage the American people to opt for a transportation mode other than the single occupancy vehicle. Increasing the price of fuel would create a direct disincentive that could ease congestion and reduce pollutant emissions.

Several studies have revealed how people perceive the costs of operating their automobiles. Hoag and Adams found that 50 percent of their survey group took into account only the cost of gas and oil (cited in Ulberg 1989, 20-21), and Westin and Watson found that 90 percent of those surveyed included only gas and oil in their cost estimates (cited in Ulberg 1989, 20-21). This research indicates that gasoline expense is perceived as the primary cost factor; associated costs such as insurance, automobile wear and tear, and licensing fees are ignored when estimating the cost of driving.

Figure 4 illustrates the relationship between the price of gasoline and the amount consumed for various countries. In the U.S., the average person consumes 400 gallons of gasoline at a price of less than $1.50 per gallon. The average consumption for the other countries listed is much lower than the U.S., approximately 150 gallons per person at $2.50 per gallon (MacKenzie 1991, 7). Figure 5 shows the number of miles traveled by mode for various countries. The average person in the U.S. traveled almost 12,000 miles by automobile and 14,000 miles total in 1987. For the other countries, the average annual per capita travel by automobile was less than 6,000 miles and less than 8,000 miles total (MacKenzie 1991, 7). Americans pay about half of what people in other countries pay for gasoline and travel almost twice the number of miles.

Figure 6 illustrates recent changes in gasoline demand as a function of gasoline price (constant 1983 dollars) in the U.S., and indicates the potential effect of future changes in gasoline price on gasoline demand. In 1980 and 1981, for example, demand for gasoline fell as the price increased and later rose as the price decreased (MacKenzie 1990, 7). Goodwin's

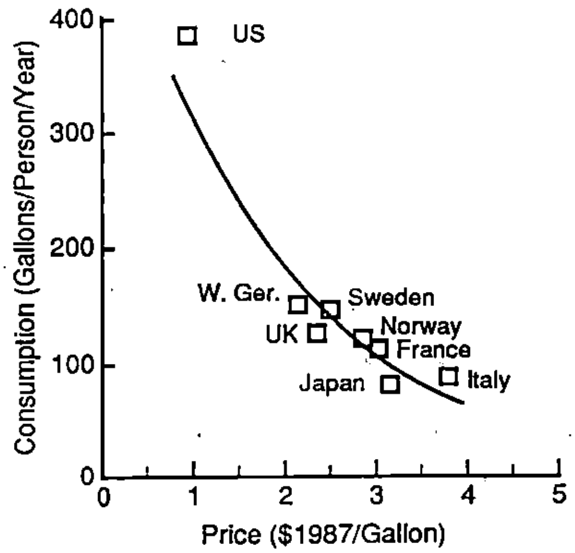


Figure 4. Consumption of gasoline

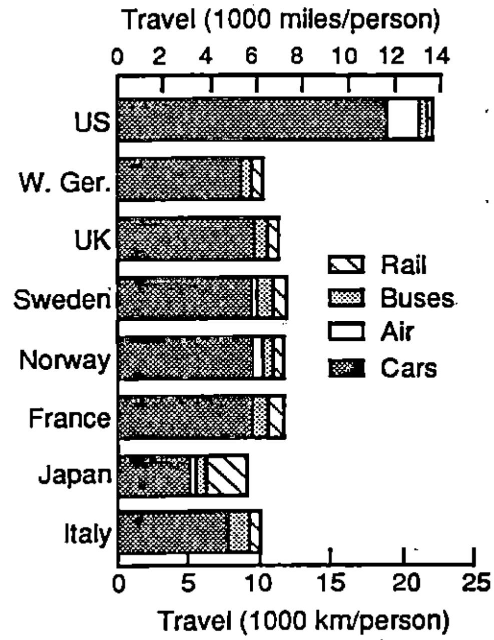


Figure 5. Annual per capita travel

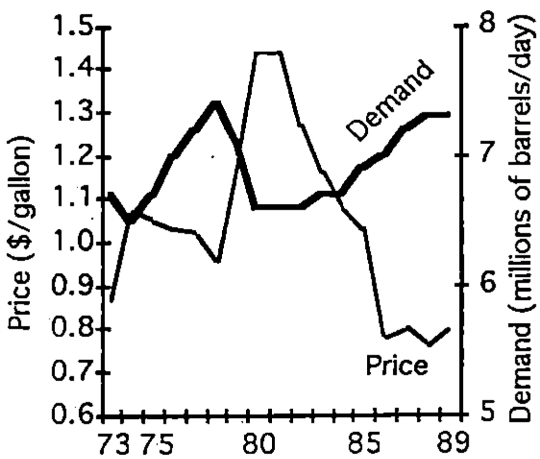


Figure 6. Price vs. demand (U.S.)

1992 review of 13 elasticity studies on gasoline consumption with respect to price found the average short term elasticity to be -0.27 and the long term elasticity to be -0.71. These elasticities indicate that if there was a sustained real 10 percent increase in fuel price, short term consumption of fuel would decrease 3 percent, while the long term effect would be a 7 percent decrease in gasoline consumption.

Of course, there are a host of factors besides the cost of gasoline that affect the amount of driving and energy consumption. Americans have overwhelmingly favored automobile use as the primary transportation mode. Heavy automobile use has encouraged, and has been encouraged by, low-density, suburban development and segregated land uses. In contrast, Europe and Japan have encouraged high-density urban villages with integrated land uses; this emphasis has given rise to a comprehensive, multi-modal transportation system. These differences notwithstanding, the low cost of gasoline in the U.S. is still one factor in the reliance on automobiles in this country.

Carbon Tax

The principle of having users pay for the environmental damage caused by their use of fossil fuels has gained popularity among economists, who argue that users would reduce their emissions to avoid having to pay for the damages. One such approach is the so called carbon tax, which would be imposed on users of natural gas, coal, or oil. Carbon tax rates would be highest for coal, followed by oil, then natural gas, reflecting the relative amount of pollutants produced by each (Pearce 1991, 31-39). Finland, Sweden, Denmark, and the Netherlands have already implemented carbon taxes, and other nations are considering a combination energy/carbon tax to deal with the increasing threat of environmental degradation, specifically the global warming associated with carbon dioxide (CO_2) (Dower and Zimmerman 1992, 32-33).

Jorgenson and Wilcoxen determined that a carbon tax on fuel of $17 per ton of carbon (in constant 1989 dollars) would hold U.S. carbon dioxide emissions constant at 1990 levels (cited in MacKenzie 1991, 6). They also estimated that a phased-in tax that eventually reached $60 per ton of carbon, or 37 percent of the price of oil (1989), would cut emissions by 20 percent between 1990 and 2005, until they fell to 80 percent of the 1990 level, and would hold them there indefinitely.

Case Study: House Resolution 1086

Congressman Pete Stark (Democrat, California) proposed House Resolution (H.R.) 1086, which called for a phased-in tax of $30 per ton of carbon. According to the Congressional Budget Office, this tax would stabilize CO_2 emissions at current levels by the year 2000. The increased tax would be:

- $18.00 per ton of coal,
- $3.85 per barrel of oil, and
- $0.48 per thousand cubic feet of natural gas.

The carbon tax would raise the price of gasoline by approximately $0.09 per gallon. H.R. 1086 would keep the real tax rate fixed by allowing it to rise with the rate of inflation (Dower and Zimmerman 1992, 11).

After further conversation with Congressman Stark's office, it was found that the gasoline tax increase of $0.09 per gallon was not directed specifically at altering driver behavior, but at encouraging industries to use cleaner fuels and non-polluting energy sources and to research solar, wind, and hydro-electric energy as these energy sources become more financially competitive. H.R. 1086 is currently pending in the Ways and Means Committee and may come to a vote in 1993 (Plumart 1992a, 1992b).

National Energy Strategy

Under the Bush administration, fuel price increases or carbon tax implementation are unlikely. The president's National Energy Strategy (NES) categorically rejects any type of oil-import fee or carbon tax because of alleged potential negative impacts on inflation and economic growth (MacKenzie 1991, 4).

According to one critic, however, one of the most serious shortcomings of the U.S. energy market lies in the fact that energy prices do not fully incorporate the negative impacts imposed on society by the excessive use of energy. MacKenzie believes that the National Energy Strategy does not address national goals because it does not allow for the implementation of market-oriented measures that would encourage the consumer to pay for the impacts just noted. He contends that if consumers were accountable for the full cost of their energy use, then their consumption would decrease, as would the environmental degradation associated with fossil fuel use (MacKenzie 1991, 4).

CONGESTION PRICING

Congestion pricing consists of roadway user fees that are higher during peak hours or in congested areas. The rationale for congestion pricing is derived, in part, from the argument that automobile users (particularly SOVs) should pay a greater share of the cost of the congestion that their roadway use imposes on the rest of the public. Congestion pricing would thus subject public road use to pricing schedules similar to those employed by telephone companies, electric utilities, hotels, and airlines, all of which charge higher rates during periods of peak demand (Orski 1992, 139-140).

Benefits of Congestion Pricing

A document developed at the 1991 Seminar on the Application of Pricing Principles to Congestion Management states that "...the principal objective of congestion pricing is to alleviate congestion by implementing surcharges for the use of selected congested facilities during peak-traffic periods" (U.S. Department of Transportation 1991, vii). At the seminar, congestion pricing proponents claimed that "Congestion charges will result in savings in time and operating costs for both private and commercial vehicles, improvements in air quality, reductions in energy consumption, and improvements in transit productivity" (U.S. Department of Transportation 1991, vii). They explained that as the surcharge for a road facility increased, trips would be shifted to off-peak periods, to higher-occupancy vehicles, to routes away from congested facilities, or that some trips would be discouraged altogether. "Congestion pricing also promises to generate large amounts of new revenues which could be used to provide improved transportation alternatives or for other purposes" (U.S. Department of Transportation 1991, vii).

Congestion pricing is compatible with the present national transportation policy because it relies on market-based strategies, pricing mechanisms, and economic incentives to efficiently allocate scarce resources. The 1990 National Transportation Policy endorses "...allowing market forces to work, minimizing government intervention and increasing flexibility of the private sector" (Orski 1992, 140).

To date, congestion pricing has only been used to decrease congestion in downtown areas, such as Singapore's; however, the principle may also be applied to highway corridors.

Toll Systems

Previous implementations of congestion pricing typically used a simple permit that was purchased by the user. In more sophisticated applications, however, new ways of efficiently detecting users, evaluating appropriate fees, and collecting payment are desired. Electronic congestion pricing systems that use advanced technology toll collection offer a way to efficiently and automatically process vehicles.

Toll systems entail charging individuals for their use of the roadway; they have traditionally been used to help offset the high cost of highway construction. In the past, toll-gathering methods have consisted of either a barrier system or a ticket system. Barrier systems charge a flat rate upon entry, usually ranging from $0.15 to $0.50. Ticket systems issue a ticket upon entry into the toll system; the user then pays a fee upon exiting that is based on the distance traveled, the type of vehicle, and/or the vehicle's weight.

Toll systems can be enhanced with Intelligent Vehicle Highway Systems (IVHS) technologies. The IVHS approach to transportation combines advanced communications, computer, control, and electronic technologies to improve mobility (Euler, Jacobson and McCasland 1990, 5). One technology that is particularly applicable to a congestion pricing strategy is automatic vehicle identification (AVI), in which vehicles are equipped with identification tags for detection and billing purposes. The system uses remote sensors to identify passing vehicles, then bills drivers automatically, allowing automobiles to pass through toll barriers unimpeded (Orski 1992, 140-141). Lanes equipped with AVI technology can enhance a TDM strategy by allowing non-stop, free access to HOVs. While some toll systems already charge high occupancy vehicles at discounted rates, the time saved by using an AVI lane can encourage ridesharing even more (Hartje 1991, 18).

Another technology that can be used with a toll system is a "smart card," which allows the driver's account to be debited by a remote sensor, eliminating the need for cash transactions and allowing vehicles to continue without stopping (Orski 1992, 140-141). An HOV discount could also be programmed into a smart-card based system to encourage ridesharing, and thus reduce congestion further.

Case Study: Hong Kong

In 1985, Hong Kong implemented the first large-scale pilot test of an AVI system. Eighteen toll sites were equipped with sensors that could detect and read identification plates installed on 2,500 vehicles. The system operated for 18 months under demanding conditions and achieved the required degree of accuracy. The enforcement system also worked well. If the automobile was not equipped with an identification number, then a snapshot of the vehicle was taken automatically, and the violator was later ticketed by mail.

While the system was technically efficient, it was not attractive politically. Participants in the system were upset about issues relating to both cost and privacy. Because automobile registration fees had recently tripled, the number of private automobiles in Hong Kong decreased, reducing the need for congestion pricing. In addition, the participants were wary of the government having access to information about an individual's whereabouts. The participants felt that privacy would be less of a concern if the toll system were run by a private company instead of the government (Poole 1988, 515-518).

Case Study: Singapore

Singapore introduced an area licensing scheme, one of the first congestion pricing experiments, in 1975. The initial objective was to discourage commuter automobiles from entering downtown Singapore during the morning peak period.

Vehicles traveling to central Singapore were required to display a special permit that cost $2.50 (U.S. dollars) a day. After this area licensing scheme was introduced, total automobile commute trips declined from 56 percent of all work trips to 23 percent. Even after a decade of rapid urban growth, traffic levels within the controlled zones were well below the 1975 predicted levels.

The area licensing scheme has been extended to evening peak hours as well.

Additionally, the Singapore government is considering changing to an electronic road pricing system within the next few years (Orski 1992, 143).

Uncertainties and Limitations

Tolls alone may not reduce traffic if charges are minimal. Several years ago, when New York doubled its bridge and tunnel tolls, there was no noticeable drop in cross-river traffic (Orski 1992, 145). Some studies have estimated that peak-hour charges would need to reach at least $0.65 to $1.15 per mile on urban roads and $0.21 to $0.28 per mile on rural roads to significantly affect commuter behavior (1990 dollars). At the same time, the more acceptable rate of $0.02 to $0.04 per mile currently charged in many toll systems has done little to deter SOV use (Orski 1992, 145). To effectively limit excessive travel, a toll system may have to charge a significant amount, provide preferential HOV treatment, and impose higher SOV rates during peak periods.§

III. HOV Mode Strategies

High occupancy vehicle (HOV) mode strategies include support programs and dedicated facilities that encourage increased use of buses, vanpools, and passenger cars that carry more than one person and thus reduce the number of SOVs and vehicle miles traveled. HOV mode strategies can be categorized into rideshare and preferential HOV treatment programs.

RIDESHARING PROGRAMS

Ridesharing is one of the major strategies for increasing vehicle occupancy and reducing vehicle trips. Ridesharing can take place using carpools, vanpools, or subscription buses. Carpools typically carry two to five passengers and travel for distances of at least five miles, one way. Vanpools carry six to 15 passengers and are cost-effective for one-way trips of more than ten miles. Subscription buses carry between 30-40 passengers and are cost-effective for one way trips of 20-60 miles (Ekistic Mobility Consultants 1990, 48). The 1990 census results suggest that carpooling can have a significant effect. If one out of seven people were to join a carpool, the effect in terms of reducing SOV use would be the same as the effect of doubling transit ridership.

The success of a ridesharing program depends in part on the implementation of several program components including ridematching services, monetary incentives, the availability of a guaranteed ride home during off-hours, program coordinator services, and promotional efforts. These are described in more detail in the remainder of this section.

Ridematching Programs

Computerized ridematching services offer the easiest and most efficient way to rideshare. Interested commuters fill out questionnaires that indicate their names, work and home addresses, and work hours. Personal information or special considerations may also be included on the questionnaire to create more compatible carpools. Applications are then processed, and computer printouts are generated; such printouts include a listing of commuters with similar work hours and home/work locations. Representatives of computerized ridematching services are available to answer questions from employees and management; they may also conduct workshops on ridesharing for employees (Berman 1991).

In the state of Washington, Community Transit in Snohomish County, Pierce Transit in Pierce County, and Metro Transit in King County are part of a regional ridematching service, that matches commuters with carpools or vanpools on a regional basis. Intercity Transit, in Thurston County, has its own ridematching service but is considering joining the regional service.

Although many companies prefer the regional ridematch service because it is convenient and comprehensive, employers may also set up their own computerized ridematching system, in which only employees within the same organization are matched with each other. Some companies find greater success with this method, as employees with the same employer have compatible time schedules and destinations.

Cash Incentives

Many TDM programs rely on special promotions or on appeals to environmental concern to encourage alternative mode choices. However, most people choose their transportation mode based on financial reasons, which is why many choose to drive alone when parking is free. TDM programs that offer cash incentives or disincentives are generally more effective than those that do not.

Case Study: State Farm Insurance

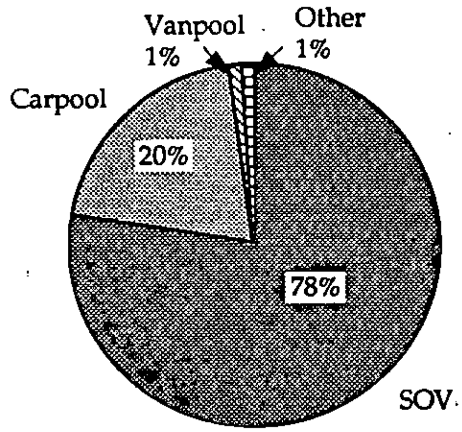
In 1989, the State Farm Insurance branch in Costa Mesa, California, was faced with the challenge of raising its employees' average vehicle occupancy (AVO) from 1.22 to 1.5. The company was required to do so under a regional Commute Trip Reduction Law, Regulation XV. At the time, the branch employed 980 people (COMSIS 1990, 148-150).

State Farm Insurance offered direct subsidies to those who chose alternative modes. The subsidy schedule was as follows:

- 2-person carpool $0.50 per day
- 3-person carpool $1.00 per day
- 4-person carpool $1.50 per day
- bicycle, bus, walk $1.50 per day

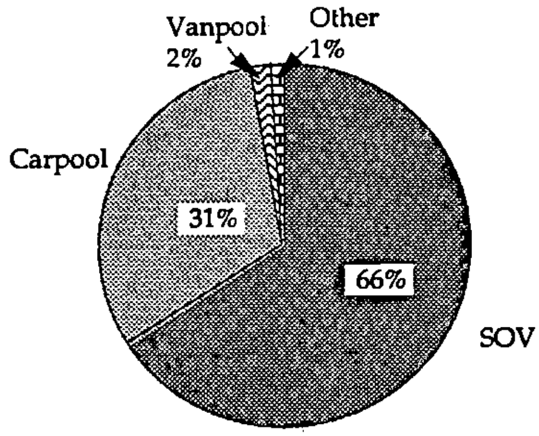
Employees received coupons every day in the parking lot, according to the transportation mode they used. Employees saved their coupons and attached them to their time sheets. Individuals could be reimbursed up to a maximum of $30.00 per month.

Before the company implemented this aspect of its TDM program in 1989, the transportation mode split was as follows:



State Farm mode split before implementation

One month after the company had implemented the changes, the transportation had shifted, as follows:



State Farm mode split after implementation

This case is significant because the only change in the TDM program was to offer employees a monetary incentive to choose a commute mode other than SOV. Many employees sacrificed the convenience of their automobile for just $30.00 per month (COMSIS 1990, 148-150).

Guaranteed Ride Home Program

A Guaranteed Ride Home (GRH) program ensures that employees who use an alternate mode of transportation will always have a ride home in case of an emergency or if they miss their regular ride home. A guaranteed ride home may be via a bus, a co-worker's vehicle, a company vehicle, or a taxi. Most GRH programs are individualized and have their own criteria regarding user eligibility requirements, mileage limits, and the number of times the service can be used per year.

Case studies confirm the positive correlation between GRH programs and higher ridesharing frequency. Ensuring a ride home reduces the employee's fears of not being able to respond to family emergencies, or not being able to work late because of carpool commitments (Lopez-Aqueres, Siwek and Peddada 1991, 9-13).

Case Study: Bellevue

In September 1987, the City of Bellevue, Washington helped implement a GRH program for employees in its central business district (CBD). Registered commuters were eligible to receive reimbursement vouchers for up to 40 miles worth of taxi service per trip. Of the 20,000 employees in Bellevue's CBD, 6,020 used an alternate mode of transportation and were thus eligible to register for the GRH program; 276 employees actually did so. After 22 months of operation, the following information about the program was gathered :

- The total program cost was $3,580, of which only $1,200 was spent on taxi fare reimbursement.
- Only 8.5 percent of the registrants had taken a taxi ride, and the number of taxi miles traveled was less than 4 percent of the total number of miles guaranteed to registrants.
- 57 percent of those surveyed in 1989 responded that the GRH program made it possible for them to continue to use an HOV transportation mode (Research and Market Strategy Division, Transit Department 1990, 1-3 and G-1).

The Role of the Employee Transportation Coordinator

The CTR law in Washington state requires each affected company to designate an Employee Transportation Coordinator (ETC). The ETC is a liaison among employees, executives, and governmental support agencies. He or she facilitates understanding of transportation alternatives and encourages employees to rideshare. ETCs also fine-tune their organizations' programs to accommodate the specific needs and preferences of employees (Lopez-Aqueres, Siwek and Peddada 1991, 9-13).

Research indicates that the presence of an ETC leads to higher rates of carpool formation and a 3 to 5 percent AVO increase (Lopez-Aqueres, Siwek and Peddada 1991, 9-13).

Promotion and Marketing

It is difficult to quantify the effect of particular promotional efforts on employees' transportation choices; studies have produced differing results regarding the link between promotions and carpooling. Nevertheless, a basic level of ongoing promotion and marketing of a TDM program is necessary to educate potential users as to available options. Items such as posters, brochures, and bulletin boards inform employees of alternative transportation modes. In addition, special promotional efforts such as drawings and prizes can be effective in increasing participation in ridesharing programs. Furthermore, the promotion and marketing effort undertaken by an organization indicates to the employee the level of management support for the program and its commitment to reducing SOV use.

Ridesharing: External Factors

Based on an extensive literature review, Lopez-Aqueres, Siwek, and Peddada (1991) compiled a set of factors that inhibit or facilitate ridesharing behavior. They found a number of external factors, beyond the employer's control, that are important in determining the number of employees who will participate in ridesharing programs.

External factors that affect ridesharing behavior include the following:

- *Employer Size.* Ridesharers are more likely to work for large employers. This association is due to the larger pool of potential ridesharers that is available in a large company.
- *Site Characteristics.* Multi-employer centers are less likely to encourage ridesharing than are single-employer centers. Coordination of rideshare programs can be more complicated for multi-employer centers than for single companies.
- *Occupational Characteristics.* Blue-collar workers are more likely to carpool than are white-collar workers. This trend is attributed to a higher rate of automobile ownership and to lower sensitivity to commuting costs among white-collar workers.
- *Commute Distance.* Ridesharers are more likely to have longer commutes than are solo drivers. The higher costs (and therefore higher potential savings) associated with longer work trips, and the relatively shorter time required to pick up fellow ridesharers during a longer commute encourage ridesharing.
- *Personal Factors.* Altruistic feelings, such as a desire to improve air quality, and compatibility with fellow carpoolers appear to be important characteristics among some ridesharers (Lopez-Aqueres, Siwek and Peddada 1991, 9-13).

Vanpool Programs

Vanpools typically carry between eight and 16 employees. Because vanpools carry a higher number of passengers, they can be much more energy efficient than carpools.

Because of the larger number of employees who must be collected, vanpools work best for round trips of more than 20 miles. Compared to carpools, personal compatibility is less of an issue because of the greater number of people involved. Vanpool coordination, however, is more of an issue. The most efficient pick-up method is to meet at a single location, such as a park-and-ride lot. However, a potential disadvantage of using park-and-ride lots is the possibility that vanpoolers may take spaces away from transit patrons at overcrowded locations (Zupan 1992, 5).

Vanpool participants typically pay a monthly fee to the owner of the van or to their employers. Some employers subsidize vanpool programs and/or eliminate the inconvenience of individual collection. In most cases, one person is designated as the driver, and as compensation, he or she may ride for free, use the van for personal use, and may receive an additional cash incentive (Zupan 1992, 5).

Vanpool vehicles may be owned by one of three parties: the employer, a leasing agency such as Metro, or an employee. If the employer owns the vans, it has both greater control and greater liability. If the employer leases the van, it has no responsibility, but it does not have as much control over the van. For example, the employer may have difficulty obtaining a van through a leasing agency such as Metro because vanpools are much in demand. Employee-owned vans are also difficult to obtain, and service quality is highly dependent on the owner. Table 7 summarizes the advantages and disadvantages associated with of each type of ownership. (Berman 1991).

Table 7. Vanpool ownership options

EMPLOYER-OWNED VANS

ADVANTAGES	DISADVANTAGES
Possible lower fares	Financial obligation
Ease of fare collection	Insurance liabilities
Tax credits	Long-term commitment
Use of van during business hours	Possible significant personnel and budget requirements
Incentives for attracting employees	

LEASING AGENCY VANS

ADVANTAGES	DISADVANTAGES
No financial responsibility	Passenger fares may be higher
No responsibility for fleet maintenance	Company has no direct control
Immediate start-up	
Experienced staff	

EMPLOYEE-OWNED VANS

ADVANTAGES	DISADVANTAGES
Employee's vehicle paid for by fares and tax benefits	Insurance coverage expensive and difficult to obtain
Possible lower fares	Driver administers program
No company investment or administration required	Driver absorbs cost of program

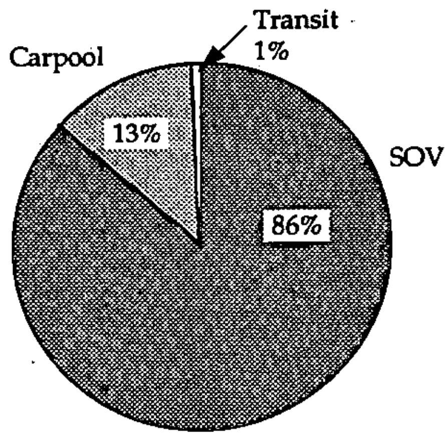
Case Study: 3M

The international headquarters of the 3M Company is located in St. Paul, Minnesota. The site consists of 24 buildings, which occupy 420 acres. Interstate 94 provides primary access to the site. The company employed 7,700 people in 1970, when it decided to implement a TDM strategy to reduce congestion and to allow for expansion (COMSIS 1990, 65-71).

The 3M TDM strategy included the following features:

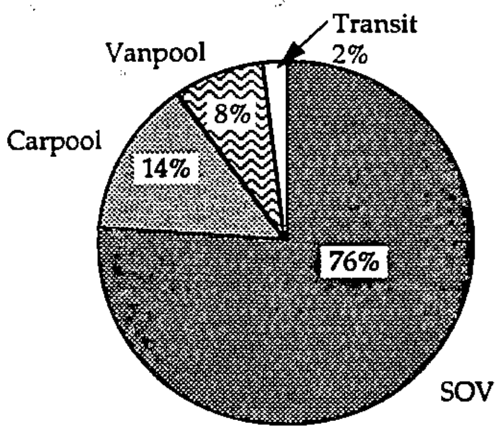
- staggered work hours,
- a subscription bus program,
- a carpool program, and
- a vanpool program.

Before 3M implemented its TDM program in 1970, the transportation mode split was as follows:



**3M Mode Split
Before Implementation**

3M did not change its program between 1970 to 1985. In 1985, the transportation mode split was as follows:



**3M Mode Split
After Implementation**

The 3M Company is most proud of its vanpool program, because it has been the primary factor in reducing SOV use. In 1985, the vanpool program provided transportation for nearly 1,000 of its 13,000 employees (COMSIS 1990, 65-71).

Subscription Bus Program

In a typical subscription bus program, the employer contracts for a bus from the local transit agency, and in return, the employer agrees to cover the bus operator's costs plus profit. The employer then assembles enough employees to participate in the program and charges a monthly fare to cover the cost that is low enough to attract solo drivers. In rapidly growing corridors, buses may eventually add trips and become regular routes. Generally, subscription buses are not efficient unless the round trip is at least 40 miles. Subscription buses magnify the advantages and disadvantages of vanpools such as lower costs to the individuals, less personal interaction, and greater use of park-and-ride lots (Zupan 1992, 5).

PREFERENTIAL TREATMENT OF HIGH OCCUPANCY VEHICLES

Preferential treatment of high occupancy vehicles (HOVs) constitutes a strategy to maximize highway capacity by increasing the attractiveness of HOV service. Freeways, arterials, and parking systems can be adjusted to create priority-based access and/or exclusive rights-of-way based on vehicle occupancy.

A comprehensive HOV priority access system offers the following advantages:

- It provides time savings and stress reduction incentives to carpoolers and transit riders.
- It extracts additional people-moving capacity from overburdened facilities.
- It lowers the total number of person-hours wasted due to congestion.
- It reduces air pollution and energy consumption (California Air Resources Board 1991, 5).

Examples of HOV systems include HOV lanes, park-and-ride lots, direct access ramps, HOV bypass ramps at metered freeway entrances, and supporting services and policies such as parking cost subsidization and ridesharing coordination (Turnbull and Christiansen 1992, 16).

HOV Facility Implementation

An extensive HOV lane network for the Puget Sound region is currently under construction. Although utilization of existing lanes ranges from 25 percent to 45 percent of capacity, they do carry a high volume of people during peak hours. For example, the southbound HOV lane of I-5, north of downtown Seattle near 145th Street N.E., carries 34 percent of the freeway travelers in 6 percent of the vehicles. On SR 520, which connects the cities of Seattle and Bellevue, the westbound HOV lane carries 40 percent of the people in 7 percent of the vehicles (Planning, Research, and Public Transportation Division 1991a, 5 and I-6).

An example of a priority-HOV facility is ramp metering with an HOV bypass lane. Ramp metering allows automobiles onto the highway one at a time; this control improves the traffic flow by distributing the vehicles more evenly. Ramp metering can result in delays of up to eight minutes for SOVs while the HOV bypass lane allows carpools, vanpools, transit vehicles and motorcycles to go directly onto the highway (Henry and Mehyar 1989, 12-13).

To improve Washington state's existing HOV system, additional priority-HOV facilities could be expanded to include ingress/egress from large parking areas, and priority treatments for HOVs on existing city streets, and new highway lanes (Ekistic Mobility Consultants 1990, 55).

HOV Lanes

HOV lanes are a tool for improving mobility in severely congested corridors. Compared to mixed flow lanes, HOV lanes "achieve from two to 20 times more person movement during peak hours at speeds averaging from 45 to 60 mph" (Fuhs 1990, 11).

However, HOV lanes are only appropriate when there is current or forecasted congestion, and where the potential for ridesharing is high (Fuhs 1990, 6). According to WSDOT's freeway HOV system policy, proposed HOV lanes must meet the following criteria:

- There must be recurring congestion in general purpose lanes. Recurring congestion is defined as a condition in which facility demand exceeds capacity for more than one hour per day, at level of service E or F. At these levels of service, roadway traffic exceeds capacity, and is characterized by erratic stops and average speeds of less than 30 mph.

- The likelihood of significant HOV use in the corridor must be high. Evidence must indicate that an HOV lane will move more people than would an adjacent general purpose lane.

- Public support must be apparent for the HOV concept; this may be demonstrated through active regional consensus in public meetings or through public surveys.

- An HOV lane may still be built, even if these criteria are not met, if such a facility would provide a system link between two previously unconnected HOV lanes that have been identified as critical for system continuity (Planning, Research and Public Transportation Division 1991b, 13-14).

<u>Case Study: San Bernardino HOV Lane</u>

The San Bernardino freeway (Interstate 10) extends east from downtown Los Angeles. An HOV lane along the freeway was opened to buses in 1973; in 1976, three-person carpools were also allowed to use it.

Researchers studied the joint bus/carpool designation extensively. Their survey results indicated that half of the carpools had formed in response to the availability of the HOV lane. Fifteen years later, in 1991, officials noted the San Bernardino freeway had achieved an average vehicle occupancy (AVO) rate of 1.38 with carpools alone, and an 1.65 AVO counting bus ridership. The AVO of parallel freeways has remained the same over the last 15 years at 1.19, counting carpools alone, or 1.25 AVO with bus riders (California Air Resources Board 1991, 9-10).

HOV Lane Occupancy

When HOV lanes are first implemented, minimum vehicle occupancy is often set at two or more passengers to encourage use. Later, when the HOV lane approaches capacity, the vehicle occupancy requirement may be upgraded to three or more passengers (Fuhs 1990, 13).

<u>Case Study: Houston's Katy Freeway</u>

HOV-lane occupancy requirements on the Katy Freeway in Houston, Texas, were upgraded from two or more passengers to three or more in October, 1988. This was the first time that occupancy requirements for HOV lanes had been increased in the U.S. The results of the shift were as follows:

- The number of vehicles decreased, which restored free flow to the HOV lane.

- The number of 3+ carpools increased.

- The number of transit riders increased.

Within four months of the change, person volume was only 6 percent less than before, and travel times were 32 percent shorter than before (Christiansen 1990, 119-130).§

IV. Trip Elimination and Modification Strategies

Trip elimination and modification strategies reduce vehicle miles traveled (VMT) by eliminating work trips and/or by reducing the number of automobiles on the roadway during peak hours. Reducing peak-hour congestion is important because vehicles operating at slower speeds and in the stop-and-go conditions associated with congestion create a disproportionate amount of air pollution.

Trip elimination and modification strategies include telecommuting, compressed work weeks, and flextime. These strategies alone may or may not reduce VMT significantly; however, case studies indicate that they may be a significant component of an overall commute trip reduction plan.

TELECOMMUTING

Telecommuting allows workers to accomplish part of their normal work load at home, rather than at the office, thus eliminating a vehicle trip to work. Originally, telecommuting was implemented via a communications hook-up between the home and the office. Although computers do facilitate telecommuting, many people are able to do their work at home with just a pen, paper, and the telephone (Mokhtarian 1991, 2).

Telecommuting has been seen as the wave of the future, and a development that President Bush has promoted as an innovative solution to traffic congestion. In a letter to the governor of California, Bush wrote, "If just 5 percent of the commuters in Los Angeles County telecommuted one day each week, they'd save 205 million miles of travel each year and keep 47,000 tons of pollutants from entering the atmosphere" (Mokhtarian 1990, 4).

Telecommuting has come a long way since its inception. It was first perceived as an option only for computer-based information workers who worked at home five days a week. Today, telecommuting has taken on another look; a nationwide survey found that only 36 percent of telecommuters owned personal computers, and that another 10 percent brought computers home from the office. Today's average telecommuter works at home only one to two days per week (Mokhtarian 1991, 1).

Although telecommuting has grown in popularity, there are some issues that need to be resolved before it can become a widespread, significant TDM strategy. Despite reports of increased productivity and employee satisfaction, some supervisors and representatives of upper management are resistant to telecommuting because of the following concerns:

- lack of control over the telecommuter's work activities,
- inability to supervise an employee's workload,
- reduced interaction between the supervisor and the telecommuter, and
- lack of input from telecommuters during work crises.

Employees, too, worry about missing out on social interaction, training opportunities, and promotions. These issues are not unsolvable, but they may prevent large-scale telecommuting implementation in the immediate future.

Telecommuting Benefits

Telecommuting is an appealing TDM strategy for many reasons. Workers who telecommute reduce the number of weekly commute trips taken, and thus reduce their weekly VMT. A telecommuting program does not require lengthy planning, design, or construction lead times as compared to new highway expansion. Moreover, it can be implemented immediately and relatively inexpensively. Telecommuting has no negative environmental impact, and it draws little public resistance. Telecommuting expands the range of personal choices by providing another commute trip option, and offers more flexibility in scheduling outside activities and associated travel (Mokhtarian 1991, 5).

Companies may implement telecommuting as a response to human resource problems as well. Many believe that the availability of a telecommuting option aids in recruiting and retaining employees. Productivity may increase as employees become better able to cope with domestic demands. Efficient use of resources, including office space and parking facilities, can be maximized as different employees use them on different days.

Telecommuting has been considered as an alternative to work trips following natural disasters. George Deukmejian, Governor of California, issued an executive order in October 1989 directing state agencies to consider telecommuting in their earthquake emergency response plans (Mokhtarian 1991, 4).

Current Research Findings

Critics of telecommuting have argued that the automobile that would normally be used by the telecommuter may instead be used by other family members, or that the telecommuter may make extra trips on the days he or she does not drive to work, thereby negating the intended benefits. However, Mokhtarian (1991) studied several sources of empirical data and determined the following about telecommuting:

- *Non-commute trips do not increase.* This finding is supported by Kitamura, et al.; and Hamer et al. (cited in Mokhtarian 1991). Data indicate that non-commute trips actually decrease; and, in some cases, trip-making for the telecommuter's household members has also decreased. Plausible explanations, which have been at least partially supported by data, include the following:
  - a tendency to link non-work activities to a commute trip,
  - the inconvenience and time involved in getting dressed to leave the house, and
  - a heightened awareness of the effects of excessive travel on the environment (Mokhtarian 1991).
- *Telecommuters tend to shift activities to locations closer to home.* Pendyala et al. conducted an in-depth analysis of three-day travel diaries that were completed by 219 workers both before and after the implementation

of a new telecommuting program (cited in Mokhtarian 1991). The data suggested a learning process in which commuters discovered and permanently adopted new services closer to their homes to satisfy non-work errands. Moreover, researchers found that the telecommuter's household members did not simply replace the telecommuter's previous longer-distance trips for these errands with trips of their own. Rather, they too adopted the destinations that were closer to home.

- *Telecommuting can motivate significant residential relocation for a small minority of workers.* Mokhtarian (1991) and JALA Associates (cited in Mokhtarian 1991) found that over a two-year data-collection period, 3 percent of the telecommuters in a California pilot project moved, or considered moving, 45 or more miles farther from their workplace after they had begun to telecommute. Of those who were considering moving, 29 percent reported that the ability to telecommute played a significant role in the choice. Based on these findings, it appears that some of telecommuting's benefits may be negated by the relocation of some participants to homes farther from the workplace, which could increase overall VMT. The study also raises the concern that this trend may increase as telecommuting becomes more common (Mokhtarian 1991, 9-10).

Telework Centers

Some employers have experimented with moving telecommuters from their homes into so called telework centers. Telework centers are closer to the employee's home and consist of office space that contains varying numbers of work stations with desk space, computers, and telephones for individual employees. Copying machines, general office equipment and supplies, a conference room/lunch room, and occasionally a satellite dish hook-up may also be available to employees who work at such centers.

While there are higher start-up costs for telework centers, they do have potential advantages for both employers and employees over working at home. The employer benefits from the following:

- a professional and businesslike environment,
- an ability to monitor the employees' worktime, and
- higher levels of security for equipment and data.

The employee can enjoy the following benefits:

- more social interaction,
- separation of home and workplace, and
- shared access to equipment and services not normally available in the home (Mokhtarian 1991, 2).

Appropriately located telework centers can offer many of the benefits of at-home telecommuting, while providing additional benefits to both the employer and employee.

Telework centers may not always qualify as a TDM measure since employee transportation to such centers still involves a commute trip, although presumably a shorter one. Also, a company may attempt to claim an existing branch office as a telework center and insist on receiving undeserved credit for reduced VMT (Mokhtarian 1991, 3).

Case Study: State of Hawaii

The state of Hawaii opened the Hawaii Telework Center in 1989. It was the first known telework partnership between the private and public sectors in the U.S.

Located in a suburban technology park 20 miles from Honolulu, the center contains 17 work stations. The public sector invested $125,000 in the project, while several private sector firms invested a total of more than $300,000 (Mokhtarian 1991, 6).

The State of Hawaii assessed the project and reported its findings, as follows:

- Each participant drove an average of 9,000 fewer miles per year.
- Participants saved an average of 350 gallons of gas and $2,500 in fuel, maintenance, depreciation and insurance costs per person per year.
- Participants reported less stress, greater work flexibility, and enhanced quality of life (Andrews 1990, E1).

The center has been in operation for more than two years; the state considers it a success and plans to develop additional centers (Mokhtarian 1991, 6).

New Technologies

A number of new technologies now allow people to accomplish a variety of tasks without leaving their homes. In this way, technology can function as a travel substitute and reduce the total number of vehicle trips. Video cameras, fiber-optic networks, satellites, and cable television are just some of the technologies being used by businesses and schools to increase access to services while reducing vehicle trips.

Many colleges and high schools are able to offer their students the opportunity to take classes from distant schools and faculty through satellite video transmissions. Such transmissions allow students to obtain high-quality specialized instruction at an affordable cost or to take advanced courses that would not normally be available to them. Some schools and businesses are also experimenting with video-conferencing, which allows real-time audio and visual interaction between two or more parties at different locations.

Retail businesses have also availed themselves of new technologies. Home shopping services, which first began with catalog sales, now use technology that allows people to have virtually any product delivered to their homes, without having to leave the house. The QVC Home Shopping Network, which displays products on cable television programs, has experienced phenomenal growth as people enjoy hassle-free shopping from their living rooms. In the Seattle area, QFC, a grocery store chain, has begun a home delivery program in which orders can be phoned or faxed in from a preprinted list of food items. QFC groups the deliveries by area and sends the groceries out within a 24-hour time period.

COMPRESSED WORK WEEK

The objective of a compressed work week (CWW) is to modify work schedules to reduce the number of work trips. The normal five-day, 40-hour work week could be converted to a work week that consists of four ten-hour days (a 4/40 program). Compressed two-week schedules could also be created by working nine-hour days and taking every other Friday off (a 9/80 program).

Case Study: Los Angeles County Department of Public Works

In September 1990, the Los Angeles County Department of Public Works implemented a 4/40 program involving 1,600 employees. The employees worked four 10-hour days, and the building was closed Fridays.

Ho and Stewart conducted a survey two weeks before and six months after the CWW implementation. They analyzed the survey data, as well as one-week travel logs, from 108 employees, and discovered the following:

- *Errand running during commutes decreased.* Employee errand trips had shifted from peak hours to off-peak, during lunch time, or mid-day on Friday.

- *The average number of trips per person per week decreased from 24.51 to 22.46,* which constituted a 9 percent decrease.

- *The average weekly VMT per person decreased by 46.43 miles,* a 17 percent reduction. However, the average time spent traveling for respondents decreased only slightly, indicating that they made more time consuming but shorter trips (i.e., more travel on minor arterials rather than highways).

- *The average participant made 4.01 trips on Fridays.* This exceeded the average number of trips made on any other day.

- *Time parameters narrowed to one hour.* Prior to CWW implementation, 94 percent of the employees arrived between 7:00 a.m. and 9:00 a.m. and 87 percent left between 3:30 p.m. and 5:30 p.m. During the CWW program, 96 percent arrived between 6:30 a.m. and 7:30 a.m. and 93 percent left between 5:00 p.m. and 6:30 p.m. The condensed arrival and departure pattern increased congestion at the work site.

- *Trips decreased on Sunday,* and no change in travel pattern occurred on Saturday. Employees used Friday and Saturday to run their errands and Sunday became a day of relaxation (Ho and Stewart 1992, 1-11).

Criticisms of Compressed Work Week

Compressed work week programs are feasible for a limited percentage of all employers. Small firms with fewer people to cover key tasks are poor candidates. It is estimated that no more than 50 percent of all employees in the U.S. work for firms with more than 100 employees. If 50 percent of those employees adopt a CWW for 10 percent of their work force, then the potential work force affected is 2.5 percent (Ekistic Mobility Consultants 1990, 44).

Employers that are large traffic generators have traditionally implemented a CWW as part of their traffic mitigation plan. However, labor laws generally specify that overtime must be paid when employees work more than eight hours at a time. Unless these codes are modified, it may be difficult to convince employers of the feasibility and value of CWW programs (Ekistic Mobility Consultants 1990, 45).

FLEXTIME

Flextime gives employees some choice in setting their own starting and quitting times. The work day may include earlier morning hours or later afternoon hours. Flextime programs may be suitable for employees in major and multiple centers that work in rotating shifts or for work places that are open for more than eight hours per day (Ekistic Mobility Consultants 1990, 59).

The transportation goal of flextime is to reduce congestion; insofar as flextime does so, it also reduces air pollution. However, because employees can still opt to arrive at work during peak periods, it may not be particularly effective as a TDM strategy. In and of itself, flextime does not reduce VMT or SOV use, but if flextime is used to facilitate schedule coordination, it may enhance ridesharing programs. However, flextime could just as easily create scheduling conflicts that would undermine ridesharing.

For example, flextime can make carpooling difficult if schedules are inconsistent, or if the carpools include employees from other firms that do not offer flextime. In a study conducted by the

Federal Highway Administration in 1986, researchers found that drive-alone rates increased and that ridesharing/transit rates decreased for three major firms in suburban Seattle after the implementation of a flextime programs. The decreases were attributed to scheduling conflicts (Ekistic Mobility Consultants 1990, 59).

Flextime studies indicate that the upper limits to its applicability are in the range of 70 percent of the work force in Washington state. Because some of that potential pool already uses flexible hours, flextime may not reduce congestion significantly (Ekistic Mobility Consultants 1990, 60). §

V. Alternatives to the Automobile

As people spend more time traveling in their automobiles, they are demanding larger and more luxurious vehicles. Ford advertises its new minivan as "a living room with an airbag." Toyota encourages drivers to feel "at one with" their cars. Automobiles may be equipped with a variety of conveniences such as compact disc players, cellular phones, electronic road maps, and even voice cues to alert drivers to certain conditions.

This kind of technology has contributed to the American mindset that the best and only way to travel is by automobile. Automobiles remain the predominant mode of transportation in the U.S. Federal policy, the expanding road network, and land use development have perpetuated heavy automobile use. Few Americans even consider trying an alternative mode of transportation. Most consider these alternatives to be comparatively inconvenient, time consuming, or dangerous.

It is unrealistic to expect people to drive less if no alternative mode of transportation is available. The following section will discuss strategies that encourage transit, walking, and bicycling as alternative transportation modes.

IMPROVING TRANSIT DEMAND

Techniques for increasing transit demand often focus on increasing transit service levels, as measured by capacity, accessibility, travel speed, and areas served. Improved service may involve increasing the frequency of service, providing preferential HOV treatment on roadways, improving vehicle comfort, extending hours of service, and extending service areas.

There may, however, be limits to these service improvements. An intensive transit improvement program can enhance work-site access for employees who commute from low-density areas to high-density areas. However, transit improvements that increase service for employees who commute from suburb to suburb are often prohibitively expensive, as are attempts to improve service for non-work related trips (Ekistic Mobility Consultants 1990, 52-53). In large cities such as San Francisco, where urban density is high and parking is both scarce and expensive, the peak-period transit mode share can reach 70 percent in the central business district (CBD) (Ekistic Mobility Consultants 1990, 52). In comparison, downtown Seattle's transit share is 35 percent (Market Advertising Communications Specialists 1992, 41).

While transit service improvements alone may not reduce SOV use significantly, transit does provide a transportation alternative and can be an important component of a TDM program. For example, transit ridership levels improve with the implementation of parking fees, transit subsidies, and preferential HOV treatment.

Alternate work hours can make transit more cost-effective by increasing demand for buses during non-peak periods.

U.S. Transit Trends

During the last decade, federal and local governments spent almost $100 billion on transit service, yet transit use in the U.S. continued to decline. The percentage of workers commuting by public transportation declined from 7.3 percent in 1969 to 6.4 percent in 1980, and has fallen since that time to the current level of 5.3 percent (Pickrell 1990, 9; Harney and Little 1992, 7A). In the last decade, the percentage of commuters traveling in SOVs has increased from 64.4 percent to 73.2 percent; carpooling, meanwhile, has decreased from 19.7 percent to 13.4 percent (Harney and Little 1992, 7A).

Transit and Land Use

The potential for expanded transit use and service is heavily influenced by any developments that encourage SOVs, including public facilities such as expanded highways, more efficient arterials, and parking lots (Ekistic Mobility Consultants 1990, 53). "With the possible exception of parking programs, strategies to improve transit service are more dependent on urban form for their economic and operational viability than any other TDM alternative" (Ekistic Mobility Consultants 1990, 53).

Public transportation is most effective in areas with high activity levels, limited parking, and good pedestrian and transit access. Benefits of a comprehensive public transportation system include increased mobility for a variety of trips, including those for shopping, commuting, school, and recreation. The degree to which public transportation system operations achieve these benefits depends, in large part, on how the community is designed, and in particular, on how land use relates to the road network (Snohomish County Transportation Authority 1989, 3-1).

Transit Facilities

Because existing land use patterns often favor the automobile, facilities that will encourage the use of transit should be developed. Potential approaches include the following:

- Increase the number of park-and-ride lots by contracting private lots from organizations such as churches. Provide the lots with additional lights and security, and locate amenities such as daycare, restaurants, and banks close by.

- Concentrate development in areas in which transit service is relatively cost effective. Density bonuses or transferable development rights can be used to encourage the density and mixed development that transit needs to be successful.

- Reduce building setbacks and construct sidewalks and shelters to create a transit-friendly atmosphere to encourage ridership.

- Provide adequate bus turnouts, bus entry and exit from developments, and adequate layover and staging areas. Increase transit's speed and reliability, important factors in increasing ridership.

- Provide access to a local circulator service, which can give transit users greater all-day mobility. Such services may connect with regional carriers and link with other modes such as light rail or express buses.

- Provide preferential bus treatment, including exclusive rights-of-way on highways, HOV ramps, HOV turning sections, and stop light priority to save transit riders time. Travel times and convenience are the primary criteria among those who are considering a mode switch to transit (Ekistic Mobility Consultants 1990, 52-56).

Transit Costs

Capital and operating costs affect transit's competitive potential to maintain, let alone increase, its share of travel. The first concern is whether transit can simply maintain its current share of approximately 5.3 percent of commuting travel, which works out to about 1.5 percent of total highway activity. National highway travel has increased three to four percent annually; even doubling transit ridership would thus amount to less than two years of growth in overall travel. In addition, past efforts that were intended to improve transit's market share have often demonstrated that improved transit service attracts carpoolers and walkers, but has a limited effect on SOV use. Given existing land use trends, maintaining this share over the next ten years will require significant effort and investment (Pisarski 1991, 7).

Future Direction of Transit

It is difficult to view the future of transit in a positive light while costs continue to increase at the same time that public transit's share of travel is declining. Fortunately, some progressive transit agencies have implemented innovative programs that have resulted in a decrease in costs and an increase in transit ridership. The following case study is an example of such a program.

Case Study: First Hill Action Plan

The First Hill Action Plan is a public/private partnership between Metro and six major public and private institutions that provides transit service to Seattle's First Hill area. These institutions provide 80 percent of the program's marginal operating costs; in return, medical and university employees receive peak-hour transit service from eight park-and-ride lots directly to this urban activity center. The First Hill Action Plan also includes the following services, which are paid by for the employing institutions:

- free taxi service that will pick up any passenger one-half hour after the last scheduled bus,
- a guaranteed ride home via transit or taxi, and
- one free day of parking per month for transit users.

Transit ridership in the area affected by this plan has increased from 209 to over 801 daily trips in one and a half years. Currently, almost 65 percent of First Hill employees commute via transit. This phenomenal growth is due in part to Metro's contributions in terms of faster travel times, more direct service, and marketing efforts. Additionally, employers have imposed parking charges of at least $50.00 per month, while offering transit pass subsidies of at least 50 percent.

The First Hill Action Plan has created a working relationship between Metro and institutions that has addressed parking problems and has allowed the institutions to save money. Metro has also benefited financially and from increased ridership. Metro recovers 54 percent of the marginal operating cost from the fare box; this compares favorably to the usual 25 percent fare box recovery rate (Research and Market Strategy Division, Municipality of Metropolitan Seattle 1992).

PEDESTRIANS

Walking is often ignored as a transportation mode; yet when feasible, it is the least expensive travel mode and the least damaging to the environment. People are generally unwilling to spend more than 30 minutes traveling to or from work; with the average walking speed at three to four miles per hour, pedestrian commuting would therefore be competitive if the one way commute distance were under two miles .

Health Issues

Walking offers a variety of health benefits. It increases the metabolism and burns up to 100 calories per mile. Walking can also improve the immune system, prevent and/or improve osteoporosis, help moderate high blood pressure, and prevent depression (Bricklen 1991, 102-105).

Dr. Ken Cooper, of the Dallas Aerobics Research Institute, tested 13,000 people on treadmills. He divided the participants into quartiles, where the top quartile had the best treadmill scores and the bottom quartile had the lowest scores. Dr. Cooper determined the death rate of the participants 19 years later and found that the top quartile's death rate was only 25 percent that of the lowest group. Those that exercised moderately were in the third quartile, and their death rate was only 50 percent that of the bottom quartile (Bricklen 1991, 102).

Transportation Problems for Pedestrians

Demographic shifts following World War II, including suburbanization, have contributed to the evolution of an auto-oriented society. To stretch road-building dollars, new roads have often been constructed without sidewalks, curbs, or other pedestrian amenities. Large parking lots have become common; their wide driveways create hazardous obstacles for the pedestrian. Fences prevent passage between buildings, and shopping malls are developed at busy intersections. As automobile convenience has assumed primary importance, the pedestrian has been ignored (Tolley 1990, 173-174).

Traffic rules and law enforcement also continue to favor automobiles. The speed limit within city limits is often 35 miles per hour; however, car-pedestrian accidents involving vehicle speeds of over 20 miles per hour produce significantly higher pedestrian fatality rates. Free right turns constitute another major pedestrian hazard, and the running of amber and even red lights has become commonplace. In Seattle, police ticket jaywalkers seven times more frequently than they ticket automobile drivers who infringe upon pedestrian rights (Tolley 1990, 175-176).

Pedestrian Improvements

Sidewalks are the most important pedestrian amenity. The sidewalk must be wide enough to facilitate ease of movement and to minimize automobile impacts such as noise, air pollution, and safety hazards. Sidewalks should be accompanied by pedestrian-friendly elements such as canopies, awnings, arcades, shop fronts, street furniture, trees, and building facades at the sidewalk edge (City of Bellevue 1990, 195). Safety improvements such as street lighting and well-designed crosswalks are desirable, especially at intersections.

Although the amenities just described encourage pedestrian movement, distance is always the most important consideration for the pedestrian. Increasing density, mixing land uses, and creating a pedestrian-friendly environment will encourage people to walk instead of drive to their destinations. Several U.S. cities including Palo Alto, California, Boulder, Colorado, and Bellevue, Washington are making this kind of effort.

BICYCLES

Using a bicycle instead of an automobile benefits society and the individual in many ways, including the following:

- no noise,
- no exhaust fumes,
- modest use of raw materials,
- modest energy consumption, and
- less harm to pedestrians.

Bicycle riding benefits to the rider include the following:

- reduced purchase and maintenance costs,
- positive health effects,

- increased flexibility,
- door-to-door transport, and
- competitive travel times for short distances and for distances of up to 3.5 miles in inner-city travel (Tolley 1990, 219-221).

The Nationwide Personal Transportation Survey (cited in University of North Carolina 1991) released by the United States Department of Transportation, showed great potential for bicycling. Of all automobile trips, "two out of three trips are less than five miles long, and four out of five are less than ten miles long" (U.S. Department of Transportation 1991, 8). The average trip length is just under eight miles; average work trips are slightly longer and average shopping trips are slightly shorter (University of North Carolina Highway Safety Research Center, 1991, 8).

Factors that Influence Bicycle Commuting

According to researchers at the University of North Carolina Highway Safety Research Center, people do not bike or walk to work for the following reasons:

- excessive distance,
- unsafe streets and/or lack of sidewalks,
- inadequate facilities (no bicycle racks or showers at work),
- driving's relative convenience and speed,
- driving's relative cost-effectiveness,
- the need to make too many trips during the day (groceries, children, errands),
- a public perception that biking and walking are not "cool,"
- poor weather, air quality, and hilly terrain (University of North Carolina Highway Safety Research Center, 1991 , 14).

Safer streets, adequate bicycle facilities, and public perception are among the factors that public agencies can influence; the other factors will continue to keep a large majority of Americans from commuting by bicycle.

Harris polls on bicycle commuting were conducted in November of 1989, 1990, and 1991. A representative sample of 1,254 adults was interviewed by telephone and the results from each year were similar. The study showed that 1.5 percent of the respondents commuted by bicycle, that 22 percent had ridden a bicycle in the last month, and that 46 percent had ridden a bicycle in the last year. Pollsters asked the respondents what incentives they would need to commute to work on their bicycles. Their responses to specific incentives follow:

- 10 percent would occasionally ride their bicycles to work if there were safe bicycle lanes.
- 10 percent would commute via bicycle if they had access to secure bicycle storage and showers at the work place.
- 10 percent would ride to work if their employers offered a financial incentive (Pena 1992, 34).

The survey concluded that the percentage of bicycle commuters could potentially increase by 10 percent if better facilities were available (U.S. Department of Transportation 1991, 10).

Bicycles and Public Transit

Transit can serve as a supplementary transportation mode for those who travel longer distances and wish to use their bicycles for part of the trip. Although one-third of all trips in the U.S. involve distances too long for bicycle travel alone, bicycle and transit could be linked. For example, a bicycle could be used to travel to and from the transit station; the bicycle would then be left at the station or carried onto the transit vehicle to provide more mobility later in the trip.

Transit systems in the U.S. have long resisted allowing bicycles onto public transportation. In contrast, bicycle access to transit in Europe and Japan has grown phenomenally. In 1982, 36 percent of the railway passengers in the Netherlands completed part of their commutes by bicycle and 10 percent to 20 percent of bus riders bicycled to transit stations. Due to limited parking, only 5 percent of those who ride the rail system in Japan can get there by automobile. Many train passengers there use their bicycles to access the rail system (Replogle 1983, 2).

A lack of secure storage for bicycles appears to keep many people from using their bicycles to access transit. At five park-and-ride lots surveyed in New Jersey, more than 20 percent of the respondents said that they would bicycle part of the time if secure bicycle facilities were available (Replogle 1983, 100). Transportation agencies in California have experimented with incentives to encourage biking to public transit. San Francisco installed 2,000 secure bicycle racks and lockers in Bay Area Regional Transportation (BART) stations, and allowed bicycles onto BART during limited hours. Bicycle arrivals at some BART stations increased by 5 percent. In 1981, the city of Santa Barbara, California, introduced bicycle trailers, which were attached to buses. The buses carried 42,000 passengers with bicycles in one year, 30 percent of whom were diverted from automobiles (Replogle 1983, 3).

Case Study: Palo Alto, California

The City of Palo Alto began considering bicycle facilities in 1967. Its first bicycle plan was passed five years later and consisted mostly of street restriping. The public had turned down previous bicycle plans because the proposals were perceived as excessively inconvenient for automobiles. Since then, Palo Alto has developed a comprehensive bicycle system that includes the following features:

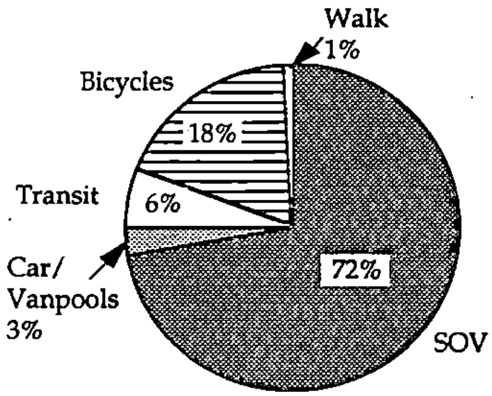
- a bicycle boulevard that is inaccessible to automobiles,
- bicycle-sensitive traffic signals,
- bicycle and pedestrian bridges, and
- unique light green bicycle lane striping (Loutzenheiser 1991, 17-19).

Palo Alto has passed more ordinances that encourage bicycle riding than has any other U.S. city. Some of them are described below:

- 1976 - Bicycle parking is required for all new developments.
- 1978 - Specified amounts of bicycle parking are required, based on the use and size of the development.
- 1980 - Monetary reimbursement is given to city employees who use bicycles on city business.
- 1983 - One shower per 10,000 square feet of building space is required and four showers for every 250 employees are recommended.
- All new or refurbished pavement surfaces must be "bicycle smooth" (Loutzenheiser 1991, 23-24).

Case Study: Xerox

Xerox, a computer-affiliated research company in Palo Alto, has offered its employees bicycle racks, lockers, and showers since 1975. Xerox employs 500 people, of whom 15 percent telecommute at least one day per week. The current transportation mode split at Xerox breaks down as follows:



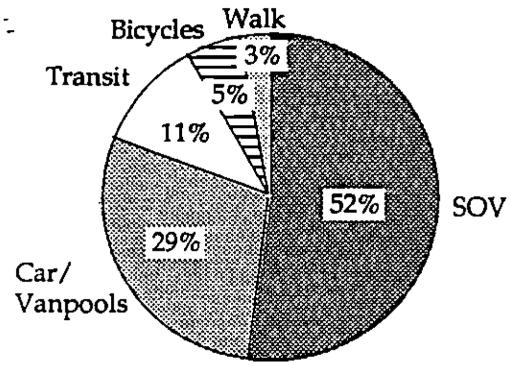
Xerox
current mode split

Bicycle ridership at Xerox is high, especially given that parking is free. Xerox attributes its high bicycle ridership to the following factors:

- increased environmental awareness,
- exercise benefits,
- flexible work schedules (employees choose variable work hours),
- a relaxed dress code,
- free soap and towels, and
- covered bicycle racks adjacent to the security department (Griffith 1992).

<u>Case Study: Varian Associates</u>

Varian Associates, in Palo Alto, offers a comprehensive TDM program that includes parking charges, transit subsidies, and carpool discounts. Varian Associates employs 3,000 people, whose current transportation mode split is as follows:



Varian Associates
current mode split

To encourage its employees to ride bicycles, Varian Associates offers enclosed bicycle storage, showers, and lockers. In addition, there is a drawing each month for a $1,000 gift certificate. Only employees who do not drive alone and those who are not subsidized are eligible for the drawing. Varian Associates does not believe that this drawing is a major factor in encouraging bicycle ridership; nonetheless, employees enjoy the recognition, and the drawing promotes alternate modes of transportation (Anden 1992).§

List of Abbreviations

AMU	Alternate Mode Usage
AVI	Automated Vehicle Identification
AVO	Average Vehicle Occupancy
BART	Bay Area Rapid Transit
CBD	Central Business District
CO	Carbon Monoxide
CTR	Commute Trip Reduction
CWW	Compressed Work Week
DOE	Department of Ecology
DPCP	Downtown Parking and Circulation Policy
ETC	Employee Transportation Coordinator
GMA	Growth Management Act
GRH	Guaranteed Ride Home
HOV	High Occupancy Vehicle
IVHS	Intelligent Vehicle Highway Systems
Metro	Municipality of Metropolitan Seattle
NOx	Nitrogen Oxides
PM10	Particulate Matter
PSAPCA	Puget Sound Air Pollution Control Agency
PSRC	Puget Sound Regional Council
SMSA	Standardized Metropolitan Statistical Area
SOV	Single Occupancy Vehicle
TDM	Transportation Demand Management
TSM	Transportation System Management
USDOT	United States Department of Transportation
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds
WSCAA	Washington Clean Air Act
WSDOT	Washington State Department of Transportation

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Glossary

Alternative mode usage (AMU)	A measure of the extent to which modes other than single occupancy vehicles are being used. AMU can be used to evaluate the effectiveness of a TDM program.
Automatic vehicle identification (AVI)	Technology in which remote sensors detect the presence of vehicles equipped with identification tags. AVI technology may be used as a component of an electronic toll or congestion pricing system to allow unimpeded vehicle movement and automated billing.
Average vehicle occupancy (AVO)	Average number of occupants per vehicle. AVO can be used to evaluate the effectiveness of a TDM program.
Barrier system	A type of toll system in which payment must be deposited before a vehicle can use a controlled roadway or corridor.
Carbon monoxide (CO)	A poisonous gas resulting from incomplete combustion. Vehicle exhaust is a primary source of CO.
Carbon tax	A tax applied to fossil fuel consumers; rates are based upon the environmental pollutant potential of the fuel.
Carpool	Two or more people sharing an automobile.
Commute Trip Reduction (CTR) law	A law adopted in Washington state in 1991. The law's intent is to improve air quality, reduce traffic congestion, and reduce consumption of petroleum fuels through employer-based TDM programs. The law mandates that the SOV mode split and VMT be reduced 15 percent in 1995, 25 percent in 1997, and 35 percent in 1999.
Commute Trip Reduction Task Force	A group appointed by the Governor responsible for establishing establish guidelines for the development of commute trip reduction plans by affected local jurisdictions under the CTR law.

Compressed work week	Alternative work schedule in which employees work a 40-hour week in less than the standard number of days, typically four 10-hour days per week or nine 9-hour days every two weeks.
Congestion pricing	Pricing of road use to reflect a user's contribution to delays caused by congestion. Pricing may be imposed through the use of tolls, permits, or electronic debit cards.
Elasticity of demand	The change in demand for a product (e.g. fuel) that results from a change in the price of that product.
Employee Transportation Coordinator (ETC)	An employee or other designated individual who is responsible for implementing and monitoring an employer TDM program.
Flextime	A system that allows employees the flexibility to schedule their working hours.
Fuel pricing	An addition to the cost of gasoline; fuel pricing can be a price disincentive to discourage driving.
Growth Management Act (GMA)	The Growth Management Act, adopted in Washington state in 1991, requires all counties that meet threshold requirements of population or growth rate (50,000 people and a population increase of at least 10 percent during the past 10 years, or a population increase of 20 percent regardless of population), as well as all cities within those counties, to develop comprehensive plans.
Guaranteed ride home (GRH)	A program to ensure the availability of transportation to employees in the event of personal emergencies or unexpected work obligations. By providing scheduling flexibility, guaranteed ride home programs can be used as a safety net to increase the attractiveness of transit as a commuting mode.
High occupancy vehicle (HOV)	Any passenger vehicle that carries more than one or two people (exact definition varies). Examples include public transit, carpools, and vanpools.
Intelligent Vehicle Highway Systems (IVHS)	The combination of advanced communications, computer, control, and electronic technologies to improve mobility.
Mode split	The percentage or breakdown of the proportion of travelers using various forms of transportation.
Multimodal	The use of more than one mode during a trip.
National Energy Strategy	A policy issued by President Bush in February 1991 that outlines future energy impacts and recommendations on how to address those impacts.

National Personal Transportation Study	A national survey of trips and travel conducted at approximately 7-year intervals. The survey provides information such as trip purpose, length, duration, and vehicle occupancy.
Nitrogen oxides (NOx)	A gaseous pollutant emitted by automobiles and other sources. NOx contributes to ozone production and acid precipitation.
Non-attainment area	Areas that do not meet federal air quality standards.
Off-peak periods	The hours of the day that experience lower levels of roadway demand (see peak periods).
Ozone	A gas caused by sunlight acting on nitrogen oxides and volatile organic compounds. Ozone is a primary component of smog.
Park-and-ride lot	A parking lot where people can leave their automobiles to ride transit or meet in carpools or vanpools.
Parking pricing	Monetary disincentives that discourage the use of SOVs and encourage HOV use.
Particulate matter (PM10)	Small airborne dust and soot particles of a certain size.
Peak periods	The hours of the day that experience the highest level of roadway demand, typically 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. (exact definitions vary).
Preferential parking	Assignment of desirable parking spaces (e.g., those nearest a building entrance) to HOVs such as carpools or vanpools.
Puget Sound Regional Council (PSRC)	Formerly the Puget Sound Council of Governments, this council is a voluntary organization of local governments of King, Kitsap, Pierce, and Snohomish counties. The PSRC is a metropolitan planning organization and provides guidance to jurisdictions on regional issues.
Ramp metering	A system that controls the flow of vehicles entering a highway corridor.
Ridematching	A service that matches employees with similar origins, destinations, and schedules to help form carpools or vanpools.
Ridesharing	A general term referring to the sharing of one vehicle by two or more commuters. Ridesharing includes carpools, vanpools and transit.
Single occupancy vehicle (SOV)	An automobile carrying only the driver.

Smart cards	A technology involving the use of encoded or electronically enhanced card-like devices. Can be used to facilitate movement through a toll system.
Staggered work hours	An employee work schedule where daily start and stop times are staggered over a period of time.
Standard metropolitan statistical areas (SMSA)	Subdivision of urban areas for statistical/analytical and database purposes.
Subscription buses	A bus service whose use is prearranged by the customer. Subscription buses may be privately contracted by passengers or employers.
Subsidy	A contribution (often by an employer) toward a portion of a commuter's transportation costs.
Telecommuting	A program where employees are allowed to work some or all of their hours at home, without having to drive to work.
Telework centers	A employer-provided facility, typically located near an employee's home, at which the employee has access to office equipment and supplies.
Ticket system	A type of toll system in which a user is issued a ticket upon entry. The user then pays a variable amount upon exiting the system, depending on the distance traveled and vehicle type.
Tolls	A charge for the use of a portion of the roadway system.
Transportation allowance	A fixed amount paid to an employee each month that represents a share of commuting transportation costs. The allowance may then be used to obtain a parking space, purchase a transit pass, etc. Some employers have chosen to pay a transportation allowance only to employees who use an alternate mode, as an incentive to reduce SOV use.
Transportation policy plan of Washington state	Planning policies and action strategies for the state transportation system are identified by the Washington State Transportation Commission and reported to the Washington State Legislature.
Transportation system management	Strategies that improve the efficiency of a transportation system, including the system's capacity.
Trip elimination	A strategy that involves the elimination of a commute trip (e.g., compressed work week, telecommuting).
Trip reduction ordinance	An ordinance passed by a city or county that (typically) requires a reduction in vehicle miles traveled or SOV use.
Vanpool	A passenger van typically used by seven to 15 employees.

Vehicle miles traveled (VMT)	The miles traveled by an automobile; VMT reduction can be used to measure the effectiveness of a TDM program.
Video-conferencing	Satellite video transmissions that allow real-time audio and visual interactions between two and more parties at different locations.
Volatile organic compounds (VOCs)	A by-product pollutant from automobile exhaust, gasoline vapors, and other sources. VOCs are precursors of ozone.
Washington State Clean Air Act Amendments	Adopted in Washington state in 1991, the amendments require areas with poor air quality to re-establish acceptable levels by December 31, 1995.

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