U.S. Department of Transportation

Implementing Effective Travel Demand Management Measures:

Inventory of Measures and Synthesis of Experience

September 1993

"Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience" is one in a series of planned reports on Travel Demand Management (TDM) provided by the Federal Highway Administration and the Federal Transit Administration. Other reports in the series include guidance manuals on employer-based and government-based TDM programs, a guidance manual for market research in TDM, and a microcomputer analysis tool (with documentation) for the evaluation of TDM projects. This report, as well as the others in the series, is intended to provide technical assistance to individuals in the public and private sectors who are reponsible for planning, implementing, operating, and/or monitoring TDM activities. The entire series of reports serve to help educate on the state-of-the-practice and guide in the development of TDM programs.

Additional information on TDM may be obtained from:

The Office of Traffic Management/IVHS (HTV-31)
Federal Highway Administration
400 Seventh Street, SW
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or

The Office of Mobility Enhancement (TTS-10)
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Final Report
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PREFACE

EFFECTIVE TRAVEL DEMAND MANAGEMENT MEASURES

PURPOSE OF THIS REPORT

Traffic congestion and the cost of providing mobility are compelling issues to planners, decision makers and members of both the business community and the general public. Transportation, and the degree of efficiency with which it is accomplished, affects us all. Therefore, we are constantly in search of solutions to our transportation problems that will give us not only increased mobility, but also greater economic productivity and a cleaner environment.

In light of these concerns, recent years have shown increased interest in measures which affect the demand side of the transportation equation. Because the resources to continue to meet transportation needs through infrastructure expansion are strained, and because travel trends suggest a worsening in the supply/demand balance, it has become necessary to see if increasing the efficiency of the travel demand itself can contribute to our efforts to improve mobility.

***Travel Demand Management** -- or **TDM**, as it is popularly known -- describes a wide range of actions that are geared toward improving the efficiency of travel demand. Much has been said, studied, and written about this subject. There is much controversy and speculation as to the strength, role, and validity of TDM solutions. This uncertainty has probably led to misunderstandings of the role and potential of TDM, and therefore, a lower yield from TDM approaches than appears to be possible.*

This report is the main product of a study that was sponsored by the Federal Highway Administration, with support from the Federal Transit Administration and the Institute of Transportation Engineers, to try to set the facts straight and provide the most comprehensive, accurate and useable guidance on TDM. The user will find in this report, and associated products available through this effort, a set of materials, statistics, guides and tools that should be of significant value in not only increasing the basic understanding of what TDM is, but on how to design and evaluate programs which will deliver the optimal potential that these strategies can offer.

LISTING OF MATERIALS

The following products have been developed through this work effort and are available to anyone with a planning or policy interest in Travel Demand Management:

IMPLEMENTING EFFECTIVE TRAVEL DEMAND MANAGEMENT MEASURES: MAIN REPORT

This report is the main product from the work effort described above. It is a comprehensive guide and reference manual on the subject of Travel Demand Management. Because of the number of topics covered and the range of information to be conveyed, the report has been prepared in three sections:

Part I: Overview: Travel Demand Management Programs

This section offers a comprehensive overview of Travel Demand Management. It covers definition and concepts, starting from what TDM is and why it exists, to where it fits in as a transportation strategy, to the types of information that are important and available when working with TDM, to barriers faced in implementation and the path to their remedy.

Part II: Inventory and Review of TDM Measures

This is the most substantial portion of the report. It catalogues and presents detailed informational profiles on each of the 11 different TDM measures. These measures include:

- Improved Alternatives to the Single Occupant Vehicle (SOV)
  - Transit Improvements
  - Carpooling
  - Vanpooling
  - Pedestrian and Bicycle Facilities and Improved Site Design Elements
- Incentives and Disincentives
  - Employer Support Measures
  - Preferential High-Occupancy-Vehicle (HOV) Treatments
  - Transit and Ridesharing Incentives
  - Parking Supply and Pricing Management
  - Tolls and Congestion Pricing

- Alternative Work Arrangements

    - Variable Work Hours/Alternative Work Schedules
    - Telecommuting/Work-At-Home Options

For each TDM action, the information which is provided includes:

(1) Description of Strategy

(2) Nature of Effectiveness

(3) Application Setting

(4) Examples

(5) Travel and Traffic Impact Potential

(6) Cost Effectiveness

(7) Implementation Issues

(8) References

Part III: Synthesis of TDM Findings

This section summarizes and interprets the findings on TDM into a *synthesis* for the reader. In contrast to the individual treatment of Part II, this section is more of a cross-cutting of information and guidance. Its organization includes:

- Synthesis of Empirical Findings

    Offers a summary of numerous Case Study examples in which employers have implemented TDM programs. Profiles for each case study review the characteristics of the site and factors leading to design and implementation of the TDM program, the measures applied in the TDM program the and resulting vehicle trip reduction. A cross-comparative analysis is then performed, identifying those factors that have low, medium and high importance to a successful TDM program.

- Effectiveness of Individual and Packaged TDM Actions

  Through use of an analytic model, tables and illustrations are provided which project the effectiveness of TDM strategies on travel when implemented in different settings, under different levels of stringency, and under different regulatory conditions.

- Cost Effectiveness

  Examines the costs incurred and cost savings associated with TDM approaches to car three different stakeholders: society at large (governments and taxpayers), employers (those who implement TDM programs), and individual travelers.

- Implementation

  Frames the issues associated with implementing TDM programs. Characterizes the settings and motivations under which TDM may be considered, and the barriers that would confront would-be implementors. Provides initial guidance as to surmounting barriers and identifies both conventional and innovative implementation mechanisms.

GUIDANCE MANUALS

Whereas the main report described above provides detailed information on the nature and potential impact of Travel Demand Management, it does not provide procedural guidance to implementing bodies. For this purpose, a series of special Guidance Manuals has been developed to give more direct guidance to persons in charge of designing, evaluating, and implementing TDM programs. The following Guidance Manuals have been developed:

Employer-Based TDM Programs

This manual is targeted to employers charged with accomplishing trip reductions through TDM programs. It provides a context for understanding TDM that is somewhat more focused than the main reference report in order to provide proper grounding. The manual then offers a special procedure that actually allows the user to design and evaluate a TDM program. The procedure determines the user's particular context and need, in terms of setting and trip-reduction requirement, then leads the user through the use of some simple charts and look-up tables that identify the composition of those TDM measures that would provide the necessary trip reduction. Implementation tips on how to incorporate key strategies are provided.

Government-Based TDM Programs

This manual is similar in intent and purpose to the Employer-Based Guide above, but has a larger scope, namely the development and implementation of TDM programs at an areawide level. Like the Employer Guide, it provides a practical orientation to TDM measures and their suitability, and then offers a worksheet-based manual procedure for designing and evaluating program options. The set of TDM strategies is broader than in the Employer Manual, since the involvement and leadership of government behind the program means that system-level strategies like transit and HOV lanes can be incorporated, as well as financial and regulatory policy initiatives. Implementation tips on how to incorporate key strategies are again provided.

TDM Market Research Guide

Practical issues face TDM program managers, such as:

- Where and how to obtain the measurement data necessary to determine starting conditions prior to developing a TDM program;
- How to determine the essential characteristics and needs of a target population, and to design and promote the appropriate alternatives and program measures; and
- How to monitor progress of a TDM program against a goal.

This manual provides helpful guidance in the identification of data collection needs, procedures for obtaining and using data to meet program design, promotion, and attainment goals.

TDM EVALUATION MODEL

A special analytic tool has been developed for use by both planners and policy officials who are concerned about the impacts of TDM. This model has been derived from the COMSIS Travel Demand Management Evaluation Model, which has been used for traffic/TDM studies around the country, and is in use by numerous States and Metropolitan Planning Organizations (MPOs) which are facing congestion management and clean air program requirements. The model is a microcomputer software system that works off of either original survey data or trip table information such as is generated and used in traditional 4-Step transportation planning systems. The model interfaces directly with planning software packages such as MINUTP, TRANPLAN, and EMME/2, and will also accept ASCII formatted data. A full User's Manual accompanies the software.

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Implementing Effective Travel Demand Management Measures:

Inventory of Measures and Synthesis of Experience

PART I: OVERVIEW

I. INTRODUCTION TO TRAVEL DEMAND MANAGEMENT

1.1 OVERVIEW

Transportation systems provide an important service to our community. They allow people to move from one location to another. They provide the means by which goods can be delivered to almost any location in an urban area. And in an increasingly changing world, they connect us as a city, a region and a nation.

Increasingly, however, the normal day-to-day operation of the transportation system is becoming a concern to elected officials, planners, the business community, and residents. These concerns relate to many different issues: traffic cutting through neighborhood roads, congestion on local roads seemingly at all hours of the day, and poor air quality because of vehicle exhausts. The underlying phenomenon, of course, is that many of our communities have experienced tremendous growth over the past several decades. And given that much of this growth has occurred in suburban areas where alternatives to the automobile are not well established, this growth has caused a corresponding increase in the number of vehicles using the road network.

For years, the solution to the rising levels of congestion was to build new and bigger roads. This encouraged still more growth to occur in these areas of now higher and better accessibility, which once again resulted in increased congestion. Although road improvements will continue to be an important strategy for providing mobility, many communities no longer have the financial resources to build many new roads, would likely face serious environmental problems, and/or encounter strong public opposition. In addition, for those urban areas not in attainment with the federal clean air standards, federal law places substantial constraints on the type and magnitude of road expansion that can be undertaken.

In many of these areas, local officials and employers are turning to a new approach for providing transportation mobility that does not suffer from these problems--***Travel Demand Management (TDM).***

1.2 WHAT IS TRAVEL DEMAND MANAGEMENT (TDM)?

Quite simply, TDM programs are designed to maximize the people-moving capability of the transportation system by increasing the number of persons in a vehicle, or by influencing the time of, or need to, travel. To accomplish these types of changes, TDM programs must rely on incentives or disincentives to make these shifts in behavior attractive.

The term TDM encompasses both **alternatives** to driving alone and the techniques or **supporting strategies** that encourage the use of these modes. The application of such TDM alternatives and the implementation of supporting strategies can occur at different levels under the direction of a variety of groups. Certainly, one level of application found in many parts of the country is at individual employer sites, or at locations where there are many employers grouped together. In this situation, the employers become the important implementers of the TDM actions, even though they may be responding to a government mandate to do so.

> ***The primary purpose of TDM is to reduce the number of vehicles using the road system while providing a wide variety of mobility options to those who wish to travel.***

Another level of application is on an area-wide basis where government agencies often direct the initiative. In this type of application, the primary focus of the TDM program is to affect as many travelers as possible within an area-wide travel system. However, experience has shown that the effectiveness of area-wide TDM programs depends greatly on the type and level of participation of employers. The development of effective TDM programs therefore should be approached from the perspective of how public officials and local employers can work together to meet the goals of providing mobility.

1.3 TDM ALTERNATIVES

At the level of the employment site, typical TDM alternatives to single occupant vehicles include:

- *carpools and vanpools;*
- *public and private transit, including buspools and shuttles;*
- *non-motorized travel, including bicycling and walking.*

TDM programs can also include alternatives to influence <u>when</u> travel occurs during a day, or <u>if it occurs</u> at all on some days. These efforts, which are usually classified as "alternative work hours", include:

- *compressed work weeks*, in which employees work a full 40-hour work week in fewer than the typical 5 days; and
- *flexible work schedules*, which allow employees to shift their work start

and end times (and thus travel times) to less congested times of the day.

A special kind of alternative which influences where work occurs and how often a trip is made is *telecommuting*. Telecommuting programs allow employees to work one or more days at home or at a "satellite work center", which is often closer to their homes and thus does not require a longer trip into the primary work location.

At the area-wide level, most of these same types of TDM alternatives are applicable. In addition, public agencies on area-wide concerns can supply:

- *Service improvements to transit service* that provide savings in costs and travel time;

- *Provision of preferential lanes* on (or access major roads to those roads) serving the area which provide time savings to those using ridesharing;

1.4 TDM STRATEGIES

TDM strategies include improvements in alternative modes of transportation; financial or time incentives for the use of these alternative modes; information dissemination and marketing activities to promote these modes; and supporting services that make the use of alternatives more convenient or that remove psychological impediments to their use. Examples of TDM strategies include:

- *financial/time incentives*, for example preferential parking for ridesharers, subsidies for transit riders, and transportation allowances;

- *parking management programs*;

- *priority treatment for ridesharers*, for example, provision of preferential access and egress to parking lots; and

- *information and marketing*, such as on-site availability of transit schedules, periodic prize drawings for ridesharers; and guaranteed ride home programs.

- Application of site or *area-wide cost surcharges or subsidy measures* designed to make the relative cost of single occupant vehicle use higher than that for high occupancy vehicles.

A typical example of area-wide cost surcharges would be parking surcharges placed on employer and public parking lots that would provide a differential cost structure for single occupant vehicles versus ridesharers.

TDM programs should be developed within the framework of overall planning for an area.

1.5 TDM IN PERSPECTIVE

An important consideration for the development of a TDM program is the relationship between the TDM alternatives under consideration and the proposed transportation improvements and land use plans for the area. In the public eye, traffic congestion is often considered an immediate problem. Quite simply, there are too many cars on the road. The solutions to this problem include all of the short-term (in relative terms) actions that were listed above. These short-term actions are really aimed at solving the more immediate issue of too many cars in one place at one time.

Of greater complexity, and perhaps of greater importance to a community, is the development of longer term congestion avoidance strategies. Such strategies necessarily focus on the root of the congestion problem and try to put in place a program that will preserve the capability of the transportation system to handle future travel demands. Congestion avoidance strategies fall mainly in two major categories--building significant additional capacity in the transportation system (such as new freeways or transit lines), and implementing land use/growth management policies that tie land use densities/designs to transportation system demand capability. Trip-making patterns, volumes, and modal distributions are largely a function of development patterns. Thus, exercising control over the trip generating characteristics of the land use (e.g., development density) can be used to make the resultant demand consistent with the existing transportation infrastructure and the level of service desired.

TDM programs should thus be developed within the framework of overall planning for an area. This planning should provide for the most cost effective transportation system improvements that reduce or alleviate traffic congestion. These improvements can include physical expansion of the highway system or additional transit services, and operational changes to improve the performance of the existing transportation system. It is no surprise that many transportation management associations (TMAs) have played a critical role in advocating improvements to the transportation system in their locale. TMA officials realize that such improvements, in concert with TDM actions, are necessary to truly enhance area-wide mobility.

The planning should also explicitly consider long-run congestion-avoidance strategies. This means that there needs to be some concern for future land use/development patterns and their impact on travel.

Taken from this broad perspective, the development of the TDM program should be viewed as consisting of complementary actions. For example, a ridesharing program (an effort to influence demand) can become more effective if some form of preferential treatment is provided enroute (e.g., a high occupancy vehicle lane) or at the destination (e.g., preferential parking), both changes to the transportation system. The effectiveness of the ridesharing program could be enhanced even further if developments were required to incorporate enhanced ridesharing activities into their design and use (a land use/development decision). A truly effective TDM program must consider how each TDM alternative and strategy complements one another.

Providing mobility in such a context thus may require, 1) innovation, 2) coordination including the participation of numerous groups, and 3) a short- and long-term perspective.

1.6 WHAT CAN WE EXPECT FROM A TDM PROGRAM?

With the right mix of TDM alternatives and strategies, a TDM program at individual employment sites can be very effective, reducing vehicle trips by as much as 30 to 40 percent in relation to background conditions. TDM programs for individual sites can be tailored to worksite characteristics, market demographics, and tripmaking patterns. Information dissemination can be targeted to a well-defined set of employees, and a corporate "culture" can be created that reinforces the TDM message. However, experience has shown that effective TDM employer programs usually employ a wide variety of TDM alternatives and strategies, each mutually supporting the overall objective of trip reduction. Figure 1-1 shows the trip reduction results from several TDM applications around the country. As can be seen in this Figure, the results vary from one location to another. However, in each case employers implemented at least one strategy that reinforced the TDM alternatives that were available to employees.

> ***Effective TDM employer programs usually employ a wide variety of TDM alternatives and strategies, each mutually supporting the overall objective of trip reduction.***

Area-wide TDM programs are not likely to produce the levels of vehicle trip reduction shown in Figure 1-1 simply because there are a variety of travel segments using the transportation system, not all of which will be affected by the TDM initiatives. The target of TDM programs are generally work trips made by employees travelling to employment sites within the subject area. In area-wide TDM applicants, however, a more diverse group of travelers is traveling to a wide variety of locations at many different times. Not only are the travelers targeted by the TDM program using the roads, but so too are travelers passing through the area and also non-work travelers plus goods/freight movements. Traffic volumes related to these other travelers could increase while the volumes associated with the TDM markets decrease, which at the

FIGURE 1-1 CHARACTERISTICS OF EMPLOYER TDM PROGRAMS

Program	Vehicle Trips Reduction	Travel Base	Type Area[1]	Preferential Reserved Parking	Restricted Parking	Parking Charges	Employer Support Levels			Legal Requirement	Employee Modal Split[2] SOV	Transit	Carpool	Van-pool
Travelers	47.9%	10,000	CBD	YES	YES	YES	Transit	Carpool	Vanpool	NO	33%	36%	19%	8%
US West	47.1	1,150	SBD	YES	YES	YES	HIGH	HIGH	HIGH	YES	26	13	60	--
NRC	41.6	1,400	ISI	YES	YES	YES	LOW	HIGH	NONE	YES	42	28	27	--
GEICO	38.6	2,500	SBD	YES	YES	YES	MEDIUM	MEDIUM	NONE	YES	40	31	20	8
CH,M Hill	31.2	400	SBP	NO	YES	YES	HIGH	HIGH	HIGH	YES	54	17	12	--
State Farm	30.4	980	SBP	NO	NO	NO	HIGH	HIGH	NONE	YES	66	--	31	2
Pacific Bell	27.8	6,900	SBP	YES	YES	NO	NONE	HIGH	MEDIUM	YES	63	2	22	11
Hartford Steam Boiler	26.5	1,100	CBD	NO	YES	YES	HIGH	HIGH	MEDIUM	NO	40	36	21	1
Swedish Hospital	26.1	2,500	ISI	NO	YES	YES	HIGH	HIGH	HIGH	YES	33	44	23	--
Bellevue City Hall	25.8	600	ISI	YES	YES	YES	MEDIUM	MEDIUM	MEDIUM	NO	52	7	29	4
San Diego Trust & Savings	22.7	500	CBD	NO	YES	YES	HIGH	HIGH	MEDIUM	YES	44	37	14	--
Pasadena City Hall	21.0	350	SBD	NO	YES	YES	HIGH	MEDIUM	NONE	YES	58	7	27	2
TransAmerica	20.0	2,700	CBD	YES	YES	YES	MEDIUM	HIGH	HIGH	YES	45	14	21	19
ARCO	19.1	2,000	CBD	NO	YES	YES	MEDIUM	MEDIUM	HIGH	YES	46	20	20	14
Varian	17.7	3,200	SBP	NO	YES	NO	MEDIUM	HIGH	HIGH	YES	62	8	21	3
AT&T	13.4	3,890	SBP	YES	YES	NO	LOW	MOW	LOW	YES	71	2	22	3
Ventura County	13.0	1,850	OSI	NO	NO	NO	MEDIUM	MEDIUM	MEDIUM	YES	69	2	23	--
COMSIS	10.5	250	SBD	NO	YES	YES	MEDIUM	MEDIUM	NONE	YES	54	18	25	--
3M	9.7	12,700	OSI	NO	NO	NO	LOW	LOW	NONE	NO	83	2	14	8
Allergan	7.0	1,250	SBP	YES	NO	NO	MEDIUM	MEDIUM	HIGH	YES	76	1	14	7
UCLA	5.6	18,000	ISI	NO	YES	YES	HIGH	LOW	HIGH	YES	74	6	10	5
Cheveron	3.7	2,300	SBP	YES	NO	NO	HIGH	MEDIUM	HIGH	YES	82	1	11	5

[1] Key: CBD = Central Business District,SBD = Suburban Business District,ISI = Inner Suburb, Isolated,OSI = Outer Suburb, Isolated, sbp = Suburban Business Park

area-wide scale could mean very little impact on congested transportation facilities. It is clear though that area-wide mandates for trip reduction are important for stimulating employer trip reduction programs. At this level of application, and with realistic levels of effort, one could expect between a 4 percent to 8 percent net reduction in vehicle trips.

Another perspective on the potential impact of TDM is the level of cost effectiveness associated with a TDM program. Accommodating travel demand through means other than single occupant vehicles can result in cost savings to three major TDM stakeholders--society at large, employers, and individual travelers.

The cost to society is in essence the cost of accommodating an additional single occupant vehicle commute trip on a crowded highway network. This cost is estimated to be $6.75 per daily one-way 10.5 mile trip ($13.50 per day). If this trip is instead handled by transit, the cost to society would be $4.10 for a trip of the same length. For a carpool, the public cost would fall to $2.70 per trip; and for a vanpool the cost would be $0.56 per trip. Clearly, the savings to society of high occupancy vehicle use can be substantial.

To the employer, the costs of a TDM program can be quite favorable. The average direct cost to the 22 employers studied in this project to reduce a one-way vehicle trip was $1.33. The net cost for the employer sample, considering parking spaces foregone and other savings to the employer, was a savings of $0.43 per one-way trip for every vehicle trip reduced. To the individual traveler, the cost savings can also be dramatic. Ignoring the value of time that might be saved through preferential treatment of ridesharers, the costs of using high occupancy vehicles are shared across more individuals using that form of transportation. Thus, for example, the cost of a van pool with 12 occupants, which includes gas, parking, and wear/tear on the vehicle, is shared by the 12 occupants, so the direct cost of travel is less than that associated with the use of a single occupant vehicle.

The implication of these cost figures is that society, employers, and individuals are all paying much more than they need to have a good level of mobility.

1.7 WHAT MAKES A TDM PROGRAM WORK? MYTHS AND REALITIES

Evaluation of TDM programs around the country provide a wide range of trip reduction results. Some employers are achieving a trip reduction of over 40 percent, while other efforts with similar levels of management commitment have produced trip reductions less than 10 percent. Why is there a difference? Importantly, is there evidence to suggest that some factors are more important than others in producing worthwhile trip reductions? The following are the myths and realities associated with

TDM programs.

MYTH 1: "Large firms have an easier time implementing successful TDM programs."

Reality: Although larger firms do often have significant resources that can be assigned to make a TDM program a success, there is no clear evidence that smaller companies have any greater difficulty. In the cases reviewed for this project, some of the smaller firms had more successful TDM programs than the larger firms.

MYTH 2: "Employer support measures such as rideshare matching, guaranteed ride home, transportation coordinators, are all I have to do to produce trip reductions."

Reality: Although employer support measures are very important in supporting TDM alternatives, they are not instruments that, in themselves, actually change behavior. A truly effective TDM program is one that provides alternatives to the traveler and then reinforces the TDM travel decision by implementing incentives and disincentives that are clearly perceived by the individual making the decision to travel.

MYTH 3: "TDM success is directly related to the type of land use conditions and transit services available to an employer at the employment site."

Reality: Having good transit service that already serves a site that experiences severe parking shortages could very well make it easier to reduce single occupant vehicle use. However, the measure of TDM program effectiveness is the level of trip reduction in relation to what is normal for that site. Thus, for example, a site could have the worst situation for trip reduction -- a heavily suburban area, no transit, and unlimited parking -- and still have a successful TDM program relative to its peers. In this case, the percent reduction in vehicle tripmaking would be more important than its modal split.

MYTH 4: "Let's put a transit line to our site, and our problems will be solved."

Reality: Where current, good transit service exists to a site, and the TDM program capitalizes on that opportunity by providing transit incentives to potential users, experience indicates that the transit service plays a key role in meeting TDM objectives. However, in those locations where transit currently is not a viable option (e.g., in many suburban locations), providing such service and developing support strategies has not been effective in attracting large numbers of drivers.

MYTH 5: "Vanpool programs are the bread and butter of our TDM program."

Reality: For many years, the premier TDM alternative offered by many employers was a subsidized vanpool program. And the experience with these programs has been positive. Those firms developing serious programs have been able to place a substantial number of their employees in vanpools. However, a vanpool program by itself often does not provide substantial overall trip reduction. Some of the best examples of effective vanpool programs in the country also have the lowest overall trip reduction performance and the highest unit costs, simply because employers placed so much emphasis on this one alternative.

MYTH 6: "We can *flex* or *telecommute* our way out of the problem."

Reality: It all depends. Flexible work hour programs can be a benefit or liability to a TDM program. If the TDM target is to reduce peak hour congestion, removing vehicles from this peak hour through alternative work hour programs will be successful. If, however, the intent is to reduce total trips or vehicle miles (such as might be the case with air quality requirements), then alternative work hour programs might be counterproductive. In addition, flexible work hours have been found to make ridesharing arrangements more difficult. The same can be said about telecommuting. Certainly, telecommuting will reduce peak hour trip making. But there is some evidence to suggest that more trips are made during the day when the employee is at home.

MYTH 7: "Carpooling is insignificant when compared to vanpools or transit"

Reality: Carpooling tends to offer modest gains in terms of vehicle occupancy relative to vanpooling or transit. In essence, it takes more carpools to reach the same level of trip reduction that can be achieved through higher occupancy means. However, the results of this study indicate that a carpooling program is a common element of successful TDM programs. The employers who thoughtfully incorporated and meaningfully encouraged carpooling, among their more "colorful" options, consistently ranked highest in overall trip reduction. The reason for this is that carpooling appeals to market segments that rely most heavily on vehicle, characteristics of the single occupant vehicle, e.g., door-to-door convenience, relaxing environment, and commitment to schedule.

1.8 OTHER REALITIES

The myths presented above are often heard in discussions that precede the creation of a TDM program. They are often founded on what is considered common sense or relate to information that is dated. There are other, perhaps more important, realities that have surfaced from this study that have not been subject to such myths. As such, they represent characteristics of TDM programs that are essential for achieving significant trip reductions.

Parking Management: Parking price and availability is a critical consideration in a traveler's decision on how to make a trip. In those situations where parking is unrestricted, efforts to coax travelers out of single occupant cars are difficult. Those sites with the best TDM program results are those where parking is restricted or managed in some way. Applying a surcharge for parking on top of restricting parking availability is a sure means of influencing the choice of travel mode. And revenues derived from these fees can be used to support the TDM program.

Subsidies: The vast majority of effective TDM programs in this study provided some sort of subsidy to those who did not drive alone. The most common measures included discounted or free parking for ridesharers and providing subsidies for transit passes. In one of the best examples of the impact of subsidies, one of the study sites which was located in a heavily suburban area, with no transit service, and abundant parking achieved a 30 percent trip reduction through progressive daily subsidies to ridesharers.

Legal Requirement: In many cases, the best examples of effective TDM programs are found in those jurisdictions that require trip reduction programs to be in place. The use of such a requirement is a good example of the interaction of the public sector responsibility for transportation system performance and the employer-based role in working with the public sector to further system performance objectives. However, the most effective legal requirement is one that is fairly specific on what targets are to be reached, probably provides guidance on measures to reach the target, and has some form of monitoring/enforcement mechanism built into it.

1.9 HOW DO WE SUCCESSFULLY IMPLEMENT A TDM PROGRAM?

DEFINING A PROCESS

The traditional way of beginning a TDM program is to examine the many different forms of organization that can be used to formalize or consolidate a TDM initiative. The TDM program for an area thus is the product of whatever organizational structure is put in place. What happens in such situations is that TDM program development becomes subject to a wide variety of concerns and pressures that tend to limit the actual program options to those not having much of an impact. This is an unfortunate circumstance for TDM proponents because when a TDM program that is designed not to do much does not have great success in trip reduction, the logical conclusion is that TDM does not work.

> ***When a TDM program is designed to provide time or financial advantages to the commuter, fewer people will drive alone during the peak. When such advantages are not provided, the program will not accomplish much.***

A better approach to implementation is to drive the process by information. There needs to be a good understanding of what the problem is and what travel markets can be targeted for "solving" this problem. Decisions can then be made on what TDM alternatives and strategies need to be put in place, and importantly what mechanisms are required for their implementation.

This process can be best described in the following steps.

(1) Determine the true nature and severity of your problem.

(2) Assess where current transportation program plans are likely to lead you in resolving these problems and identify shortfalls where TDM strategies could be appropriate.

(3) Using information, explore a range of TDM options available to you and assess the impact they will have on your transportation problem, with little concern at this point whether they are implementable.

(4) Study the tradeoffs among the different alternative approaches regarding cost, timing, impact and other criteria important to local decision makers. Decide which TDM measures would be most effective to implement.

(5) Decide what mechanisms you will need to implement your chosen program.

It seems clear that areas interested in TDM could be approaching the task of TDM program development from different starting points. Some areas have a good understanding of the nature and severity of the problem. Others do not. Some planning agencies already know what portion of the problem will be handled by proposed projects. Others do not. The proposed process suggested above therefore should be considered a general guide, with the specific steps that need to be taken determined very early in the process.

DEFINING AN IMPLEMENTATION STRATEGY

Because by their very nature of trying to change human behavior, many travel demand management strategies are very often difficult to implement. Successful designs of TDM programs call for combinations of actions and action strategies. In addition, employer, employee and public agency participation is deemed critical to overall success. In most cases, the success of these actions relate to the fine level of attention paid to the details of implementation. Who were the constituencies most likely to support the strategy? What advantages will private employers see to their participation? How do we obtain top management commitment to demand management? How do we put together the private sector and public official coalition that is necessary for progress? These and many more issues often need to be addressed before TDM strategies and programs are implemented.

The key to a successful TDM program is therefore an effective implementation strategy. The best TDM plan will go nowhere unless great thought has been given to what steps need to be taken by whom. Success in putting together effective TDM programs lies in developing four basic ingredients--*commitment, constituency, coordination and constituency*. The development of the implementation strategy could very well lead to serious considerations of new institutional arrangements (e.g., management associations) and new financial mechanisms (impact fees) designed to

> ***Success in putting together effective TDM programs lies in developing four basic ingredients--commitment, constituency, coordination, and continuity.***

fund TDM. Importantly, unless the area-wide or employment site TDM officials continue to monitor, assess, and adjust the program, it is likely that program effectiveness will decline.

Experience with TDM programs throughout the U.S. has indicated that there are three major areas where obstacles to implementation seem to arise: *motivation, empowerment*, and *perceptions*. Each of these is discussed below.

Motivation: TDM actions often represent substantial change from existing norms of behavior. This change could occur in organizational philosophy, approaches to finance, the process of decision-making on land use, infrastructure or transportation service provision, and, most fundamentally, in individuals' travel behavior. Change is often difficult to achieve. And thus, some form of motivation is necessary to achieve or implement change. With relation to TDM, this change might focus on the developer to design a project that is conducive to TDM; the employer to find alternative ways for employees to travel to work or to locate in an area where employees will have the best travel and housing options; the individual traveler to consider using an alternative to driving alone; and the household to take advantage of residential locations that minimize commute distances and maximize availability of alternatives.

At its most basic level, the motivation for TDM participation is primarily one of self benefit. By implementing a TDM program, will the participants meet the requirements of a state or local statute and thus avoid the sanctions and/or embarrassment of non-compliance? Or, will the TDM program greatly ease the congestion problem in an area and thus make the commute easier? Or, by encouraging multi-occupant vehicle commutes, can the capital or leasing expense of future parking expansion be avoided?

No matter what the reason(s), the participants in a TDM program must be motivated to participate. The key challenge to those who are the initiators of the TDM program must be to motivate other participants to join the program. To do this, one must ask what is likely to motivate participation? What services are to be provided to participants that they might feel are beneficial? Or, what negative implications of non-action need to be emphasized to convince possible participants?

Private employers and corporate managers are key participants of TDM programs. Because the organizational culture of these participants is based on responding to top management direction, the successful inclusion of these participants in a TDM program requires that top management be committed to the program. Often, meetings are held early in the formulation stage to simply enlist top corporate support for TDM programs. The importance of these meetings thus rests in convincing corporate leaders of the importance of their participation and in sending this message to those subsequently responsible for implementing individual corporate elements of the program. The corporate leaders must be able to determine clearly what benefits will accrue to their company by participating in the program. In other words, they must be motivated. And, as the TDM program evolves over time, this motivation might change. For example, corporate leaders located in a high growth, congested area might enthusiastically endorse a transportation management association that is primarily involved in ridesharing activities. However, as congestion lessens or economic circumstances requires corporations to cut back their number of employees, the TMA might have to refocus its services and, once again, motivate corporate leaders to participate. There is some evidence to suggest that this is exactly what is happening in those areas of the country facing a downturn in economic conditions.

Providing motivation presupposes that there is some group able to do so. Experience with TDM programs around the country shows that the most successful programs are those which have some local body or corporation which is willing to champion a TDM program. It is usually this champion that provides the initial outlay of entrepreneurial energy which rallies other groups to participate. Public agencies are often not able to serve in this champion role. Many public agencies must work within existing institutional confines, or have restrictive geographic venues. Some governments lack sufficient power to direct other governments, or to work across jurisdictional boundaries. In addition, government agencies often have no effective means of involving the private sector in its activities. Finding a champion in such an institutional structure who can then motivate other participants is probably the most important obstacle that must be overcome in the implementation of TDM programs.

Empowerment: Once there is agreement among the participants to form a TDM program, there needs to be political, organizational, technical or financial capabilities that empower the participants to carry out the program. For example, a review of TDM programs in the U.S. indicated that the existence of a local TDM ordinance is a key factor in the successful implementation of TDM programs. Without such empowerment, local interests have a weak basis for generating support behind such a program. Likewise, inadequate legal and regulatory powers of municipalities or management organizations to implement or enforce TDM programs is a significant detriment to implementation.

Along with political or regulatory empowerment, funding is another important resource that allows TDM participants to implement an effective program. Although TDM strategies are often considered low-capital actions, funds are still necessary to provide the initial investment in planning or marketing that serve as the foundation of a good TDM program. And, in other cases, strategic transportation projects (a park-and-ride lot) or services (bus shuttles) might be necessary to make the program work. Some of the most effective TDM programs have occurred where the state government, most often the state department of transportation, has provided matching funds to locally generated contributions.

Another form of empowerment is the technical skills necessary to analyze, develop and implement a successful TDM program. Important skills and capabilities include:

- Understanding the nature of the suburban mobility problem, the trends and relationships which have produced the problem, and consequently why new highways alone cannot solve the problem.

  Having a basic understanding of the relationship between land use patterns, auto dependency, and travel behavior.

- Being aware of the "menu" of TDM options, and having a sense of the travel markets/situations where they are most applicable; separating traditional perceptions about the appropriateness of particular solutions from objective evidence.

- Having the technical tools, information and training to properly evaluate the effectiveness of the different options.

- Having knowledge of how to manage the "process" of TDM, in terms of organizational development, education, outreach and promotion, consensus building, implementation and sustenance of the effort.

When such technical capability does not exist, TDM advocates often have a difficult time showing the benefits of the program and in developing the most effective application. Although technical resources are most important in the initial formative stages of a TDM program, the on-going effectiveness (and mid-stream corrections) of TDM programs often require constant technical analysis and evaluation.

Perceptions: There is often a great misunderstanding on what TDM can accomplish, and perhaps an even greater misunderstanding of what the different actors involved have to offer. In particular, in those situations where the TDM program involves the participation of both private and public sector representatives, there can be serious misperceptions of the motivations and roles of each group. Even within each sector, there are often preconceived notions on what different actors will likely contribute to the development of the program. Highway agencies are viewed as wanting to expand highway capacity. Transit agencies are viewed as mainly interested in providing fixed-route bus service. Planning agencies are viewed as global thinkers, with little ability to contribute to operations-oriented strategy formulation. Developers are perceived to be mainly interested in profit. Employers are considered to be unconcerned with employee transportation. Many of these preconceived notions must be overcome before any concerted effort can be undertaken in developing a successful TDM program.

1.10 IS TDM WORTH THE EFFORT?

The answer to this question lies with you. TDM has proven to be an effective approach to reducing trips. However, it is not a panacea. TDM requires thoughtful examination of the alternatives, and careful planning of their implementation. Every time an employer sets work hours, or city officials deal with parking requirements and prices, or a transit agency sets fares, travel choices are affected.

The relationship between area-wide initiatives and employer-based efforts also needs to be considered. And perhaps most importantly, successful TDM needs a commitment to proceed, the development of a constituency that will support its efforts, the coordination among the many different groups that can affect a community's mobility and provision of a program of action that results in continuity over time.

Implementing Effective Travel Demand Management Measures:
Inventory of Measures and Synthesis of Experience

PART II: INVENTORY AND REVIEW OF MEASURES

II. INVENTORY AND REVIEW OF TDM MEASURES

The purpose of this section is to give the reader a basic reference guide on TDM measures. The section provides a basic classification of and introduction to 11 different categories of TDM measures. Considerable detail is afforded to the description of what each measure is, how it works, where it fits in, and what its contribution may be to transportation management goals.

This section of the report can be viewed as a *catalogue* of TDM measures, with sufficient information on each measure that the reader can properly understand its nature, application and potential. The development of a particular program must incorporate the best features of individual strategies in order to create the most effective package for addressing the needs of the particular setting.

It is convenient to think of TDM measures as falling into the following basic categories:

1. Improved Alternatives

If we desire to reduce the demand for single-occupant-vehicle (SOV) travel, then we must maximize the availability and quality of the basic alternatives offered to the traveler. These include transit, carpooling and vanpooling, and bicycle and pedestrian systems.

2. Incentives and Disincentives

Despite our best efforts to develop alternatives to the SOV, characteristics of the current land use and policy environment convey significant advantages to SOV users. In order to make the alternatives sufficiently attractive to encourage their use, it is necessary to consider various inducements could cause the traveler to re-evaluate his/her choices. These inducements range from "incentives" to non-SOV users to "disincentives" for SOV users, and can range from informational and support actions to the alteration of existing travel time and cost relationships.

3. Alternative Work Arrangements

A somewhat different type of alternative to shifting travelers to high-occupancy-vehicle (HOV) travel modes is shifting the time of travel from congested peak periods, or to reducing the actual frequency of travel by changing the underlying need to travel to a worksite on a daily basis. These types of actions may or may not support shifts to more efficient modes, and hence are dealt with as an independent class.

The particular TDM measures which are included in this *catalogue*, and the order in which they are presented is as follows:

A. IMPROVED ALTERNATIVES

A.1 Transit Service Improvements

A.2 Carpool Programs

A.3 Vanpool Programs

A.4 Bicycle/Pedestrian Facilities and Site Improvements

B. INCENTIVES AND DISINCENTIVES

B.1 Employer Complementary Support Measures

B.2 Preferential High Occupancy Vehicle (HOV) Treatments

B.3 Economic Incentives

B.4 Parking Supply and Pricing Management

B.5 Tolls and Congestion Pricing

C. ALTERNATIVE WORK ARRANGEMENTS

C.1 Variable Work Hours/Compressed Work Weeks

C.2 Telecommuting

Upon reviewing the presentation in one of these sections, the reader will find the following information:

1. DESCRIPTION OF STRATEGY

A characterization of what the particular type of TDM measure is, where it falls categorically in the list of actions, and the different forms the measure can take.

2. Nature of Effectiveness

Describes how the measure affects travel behavior, and in the process communicates how the measure is strategic and why it is important. In appropriate instances, the section also points out what the measure does not do or is incapable of doing, and how it may be misperceived and misapplied and fall short of its potential.

3. Application Setting

Describes the environments in which the strategy is likely to be most effective, including type of travel market, employment-base characteristics, and land-use patterns/density. Also, describes packaging in which the measure is likely to be most effective, in terms of those TDM measures and regulatory/support vehicles that are associated with the most successful implementations.

4. Examples

Provides a range of real-life examples where the measure has been successfully applied.

5. Travel and Traffic Potential Impact

Provides a synthesis of the performance of the measure in changing travel behavior and reducing vehicle travel and traffic congestion.

6. Cost Effectiveness

Describes the costs and benefits associated with the measure, and offers a profile of the potential cost savings/burdens in implementing the measure.

7. Implementation Considerations

Not an implementation guide, this section alerts the reader to the types of barriers that may be encountered when trying to properly implement the measure, and offers insight into how they have been or may be resolved.

8. References

Provides a bibliography of relevant source materials for the reader who wishes to develop additional knowledge on the measure.

A. IMPROVED ALTERNATIVES

Transit Service Improvements
Carpool Programs
Vanpool Programs
Bicycle/Pedestrian Facilities and Site Improvements

A.1 TRANSIT SERVICE IMPROVEMENTS

1.1 DESCRIPTION OF STRATEGY

For years, transit's major role in urban areas was to serve the "downtown", i.e., the regional urban core, where high trip densities created both the need for commuting alternatives, and the opportunity for transit to move large numbers of people efficiently. Transit has been most productive in serving city centers. However, congestion is growing in the suburbs at a more rapid pace than in the downtowns. Transit systems everywhere are facing the same challenge: how to provide a reasonable quality of service to the less densely-developed areas scattered around the metropolitan area, within increasingly restrictive budgetary limits. Part of the answer is that traditional transit services will never be able to meet all the needs of less dense areas in a cost-effective manner. At best, transit can become part of the solution to the suburban mobility problem, but cannot become the entire solution. Further, it can become part of the solution only by developing innovative service improvements and implementation strategies, including a greater involvement by the private sector in the planning, operation, and financing of such services. In this context, this section will mainly focus on the potential role of transit services in addressing the needs of commuters outside of the traditional downtown environment.

Three types of actions will be considered:

(1) New Services,

(2) Service Improvements, and

(3) Connective Services.

NEW SERVICES

In many metropolitan areas, a potential exists for providing transit service to activity centers which are not presently served. This service could be a brand new route, or an extension of an existing route. It could be part of the area's public transit system, or operated independently by a private company. In addition, a "tailored" bus service, designed to meet the need of a specific population (normally, the residents of a particular area or the employees at a particular location) would fit into this category. Examples of such a service include buspools and subscription bus services, both of which provide express service to or from specific locations, with a limited number of stops at either end of the trip.

SERVICE IMPROVEMENTS

Various strategies can be used to provide a more competitive and efficient transit service.

- ***Reduce wait time***: increase service frequency, modify routes to reduce headways in certain areas, institute a timed transfer system;

- ***Reduce riding time***: run buses in limited-stop or express operation, construct freeway or arterial bus lanes ("transitways"), implement traffic signal preemption for buses, restructure routes to provide more direct service;

- ***Transit terminals***: construct or enlarge park-and-ride lots, develop transit transfer centers, construct bus stops and sidewalks within suburban activity centers;

- ***User cost:*** implement a fare prepayment plan, fare passes, coordinate fare policies across service providers, subsidize fares.

CONNECTIVE SERVICES

In many cases, activity centers are relatively isolated from other economic activities which are considered important by employees. For example, having easy access to retail, restaurants, and other support activities (e.g., day care) can be very important in one's decision to use an automobile for mid-day travel, or perhaps even in the decision to drive to work. In addition, several studies have shown that an important perceived barrier to using transit is the difficulty in reaching a destination once the transit portion of the trip is completed. In such cases, all that may be needed is a short-distance, high-frequency shuttle service to facilitate transit use. Peak period shuttles to nearby transit stations can link an employment site to an existing route, which may prove particularly beneficial for "reverse" commuters (persons who live in the city and commute to jobs in the suburbs).

1.2 NATURE OF EFFECTIVENESS

In general, a traveler will use transit for one or more of several reasons: time savings, cost savings, convenience, and transit dependency.

TIME SAVINGS

Travel time has long been recognized as one of the most important variables affecting travelers' decisions. Almost all studies of work-trip mode choice indicate that commuters prefer travel modes that have the shortest travel time, all other things being equal. Thus, transit's success in attracting riders is roughly proportional to its ability to save the commuter some time, compared to alternative modes. Travelers evaluate their options on a door-to-door basis. Therefore, when they evaluate a transit service, they consider not only the time spent onboard the vehicle, but also how far they have to walk (or drive) to reach it at either end of the trip, how long they have to wait, and whether they have to transfer to complete the trip. Transit service must compare favorably with the private automobile in total door-to-door travel time, or be able to make up the difference in some other important way (see "Convenience" below).

Transit travel time is composed of two elements: ride time and access/wait time. Considerable research has shown that travelers view these times differently: access/wait time is seen as roughly 2.5 times more burdensome than ride time. Thus, a minute of access/wait time savings is as important as 2.5 minutes of ride time savings, with respect to influencing the mode choice of commuters. Transit ride time is related to the operating speed of the vehicles, while access/wait time is a function of the density of the route network, the frequency of service, and the provision of effective transfer opportunities.

COST SAVINGS

Commuters perceive the cost of using transit in two contexts: 1) how the transit fare compares with the cost of driving and parking, and 2) ease of fare payment. Few commuters are aware of the true "hidden" cost to themselves or to society of driving one's own auto. History has shown that only in times of relative fuel scarcity (and attendant extraordinary price increases) have commuters given a great deal of thought to the cost of driving. An exception to this occurs when a major toll facility is present: in such cases, motorists tend to be acutely aware of the toll, especially given that toll payment is often accompanied by a loss of time waiting in a toll booth queue. Parking cost increases have been shown to be effective in motivating modal shifts to transit. This is probably because parking cost is seldom hidden: the commuter must confront it every day, week, or month.

Ease of fare payment is an important characteristic for many market segments that transit agencies might be targeting (e.g., the elderly or tourists). If this transaction is confusing or considered onerous, the transit service might have great difficulty attracting riders.

Convenience

Some commuters find transit to simply be more convenient than driving. Some individuals do not like to drive (particularly during congested hours) because of the stress, or they may prefer to read or sleep during their commute. Others want to save wear and tear on their automobile, or may face inconvenient or scarce parking at their workplace (even though it might be free). Although it is generally impossible to objectively measure these "quality of travel" conditions, for some people they are equally as important as quantifiable time and cost savings. Transit is also considered by some to be more convenient than car- or vanpooling. Transit service that offers a choice of three or four departure times during the peak period is certainly more flexible than a pooling arrangement that offers only one departure time.

Some commuters, however, consider themselves to be "SOV captive." That is, they feel they need to drive because they make other stops to/from work or for mid-day errands, because SOV provides more comfort and privacy, because an SOV might be perceived as a status symbol, or for other reasons unrelated to the actual time and costs involved. For these people it is doubtful that improved transit service would ever convince them to switch travel modes.

Transit Dependency

The above three reasons apply primarily to commuters who have ready access to a private SOV and thus have some true measure of discretion as to whether to use transit. However, lower-income workers and those with disabilities may not have a clear choice. Such travelers are considered to be "transit captive" and are generally limited to jobs that are accessible by transit. This includes people who are "choice-captive": commuters who might be able to afford an auto, but who allow their primary vehicle to be used by other household members (whose trips might not be served by transit). An important issue in serving the transit-captive population concerns "reverse commute" transit service. This involves transporting lower-income residents from inner city areas to suburban jobs, using vehicles running in the "off-peak" direction.

EFFECTIVENESS OF SUBURBAN STRATEGIES

New Services

Providing service where none existed before provides commuters with a new travel option although the mere existence of bus service does not guarantee that riders will use it. Extending an existing route at the residential end expands the coverage area and makes the route accessible to more people. Tailored bus services such as buspools are effective because they offer fairly direct service from home to work, usually with only a few stops. Buspools which use over-the-road buses and serve only one workplace often enjoy an high-quality, exclusive image among commuters. Fare prepayment schemes that are typical of buspools further enhance the attractiveness of such services.

SERVICE IMPROVEMENTS

- *Wait Time:* Wait time is related to service frequency and the need to transfer. Increasing frequency reduces initial wait time and enhances the flexibility of the commuter's schedule. Where transferring is unavoidable, a timed transfer system can almost eliminate transfer wait time and the uncertainty associated with transferring.

- *Ride Time:* A common complaint about transit service is that the routes do not provide a sufficiently direct path from home to work. As regional growth patterns change, it will be useful to consider restructuring bus routes to provide a shorter path between suburban residential and employment locations. Such restructuring saves not only riding time, but also may reduce the need to transfer, thus saving wait time. A new suburban route structure with these goals in mind was recently implemented with some success in Bellevue, Washington. For routes which are already direct, the provision of signal preemption, a separate freeway bus lane, or a toll bypass facility can give buses a time advantage, especially if a chronic traffic congestion point is bypassed. Experience in Houston and elsewhere has shown that such facilities must provide buses with a total time savings of at least seven minutes compared to driving alone, in order to be considered competitive.

- *Transit Terminals:* In low-density residential areas, it is generally not cost-effective to provide enough service so that everyone can walk to a bus. It is often preferable to concentrate bus service in a corridor so that a park-and-ride served by many buses can minimize overall wait time. Secure, well-lit, and free suburban park-and-ride lots in uncongested suburban areas are very effective in increasing the convenience of transit, especially for longer trips. Sometimes, "peripheral" park-and-ride lots are established on the edge of downtown (or other built-up areas) to intercept drivers before they reach the most congested areas. By providing free or low-cost parking and shuttle bus service, such lots are effective in reducing downtown traffic. They may also increase convenience, depending on how difficult it is to find parking downtown. Finally, the workplace end of the trip is also a candidate for improvements. Often, suburban developments are set back so far from the public street that the walk from the street to the buildings can be prohibitive. The provision of sidewalks and close-in bus shelters not only saves walking time, but improves security and convenience for waiting passengers.

- *User Cost:* Fare subsidies encourage transit use by making it more cost-competitive with the private SOV. In addition, the negative effects of exact fare programs and complicated fare policies cannot be overlooked. Fare prepayment programs can greatly simplify what to many commuters seems an unnecessarily complicated transaction, thereby removing a non-trivial barrier to transit usage.

From the point of view of the transportation system, there are obvious potential benefits to replacing 40 or more automobiles with one bus or rail car: reduced traffic congestion, reduced energy consumption, reduced air pollution, and less space devoted to serving the automobile. Such benefits are proportional to the number of people who switch from driving alone to using transit. However, there is also a cost of providing the service that is rarely completely paid by the rider. Numerous studies and service demonstration programs have concluded that this cost is justified only when the benefits are large. The benefits can be realized only when transit is implemented in the right setting: one in which the trip densities are large enough, and the service is competitive enough, to attract sufficient ridership.

1.3 APPLICATION SETTING

TRAVEL MARKETS GEOGRAPHIC SETTING

In the spectrum of TDM actions, transit service is a "high end" strategy which requires a relatively high density of trip ends for it to be successful. Traditionally, this has meant fairly long routes serving a corridor radiating out from a region's Central Business District (CBD). Work trips are most readily served due to their concentration in space (the CBD) and in time (peak hours). However, suburban environments seldom provide a sufficient concentration of jobs per square mile, and usually tend to draw workers from a more widely scattered area than the traditional transit corridor.

Table 1-1 was adapted from a comprehensive study of urban densities and public transportation, provides guidelines on the size and concentration of development at the residential and workplace ends that are needed in order to justify various forms of transit service (Regional Plan Association, *Where Transit Works*, 1976):

TABLE 1-1

Size/Concentration of Development (Residential and Workplace)

Type of Transit Service	Peak Headway[1] (minutes)	Minimum Residential Density (dwelling units/acre)	Min. Downtown[2] Size (million sq. ft. non-residential floor space)
Minimum Local Bus	60	4	3.5
Intermediate Local Bus	30	7	7
Frequent Local Bus	10	15	17
Express Bus Walk Access	30	15 (avg. over 2 sq. mi.)	50
Express Bus Drive Access	20	3 (avg. over 20 sq. mi.)	20
Light Rail	5	9 (avg. over 25-100 sq. mi.)	30
Rapid Rail	5	12 (avg. over 100-150 sq. mi.)	50
Commuter Rail	≈45	1.5	75

[1] Headway = time between transit vehicle arrivals.

[2] "Downtown" is defined as a contiguous cluster of non-residential use and is larger than the more narrowly defined Central Business District.

Another way of viewing this is to consider each travel corridor from the perspective of the minimum passengers volumes needed to justify further consideration of a given transit mode. Table 1-2 displays such volumes, referred to as "Initial Screening Criteria for Modal Options" are as follows (Barton-Aschman Associates, *Virginia Commuter Study*, 1982):

TABLE 1-2

Initial Screening Criteria for Modal Options

Type of Transit Service	**Minimum Corridor Volume (1-way, peak-hour, peak-direction person trips)**
Express Bus	3,000
Light Rail/Busway	8,000
Rapid Rail	17,000
Commuter Rail	17,000

The reason why such high volumes are needed to justify transit service is that, compared to other TDM measures, transit is a rather expensive strategy. Fixed guideways, terminals, and other facilities are considered major capital intensive projects. Buses cost about $200,000 each and rail cars cost about $1 million each. The cost to operate one bus for one hour is about $90 in many metropolitan areas. One key reason why the cost of transit is so high compared to, for example, carpools is that it is usually part of an extensive system which often utilizes large vehicles to move large numbers of people. If that capacity is not well-utilized, then the funds used to provide the service will not be as productive (in terms of SOV's or vehicle miles of travel (VMT) removed per dollar) as they might otherwise be. In short, transit service can be effective and efficient in removing SOV trips from the roadways only where there is enough demand to justify the costs of providing service.

Once it is determined that there is sufficient demand to make it feasible to consider transit service, the next issue is whether transit can be competitive enough in a particular setting to attract enough trips to provide a reasonable revenue/cost ratio (or cost per SOV trip removed, or other similar measure). As noted above, there must exist a time savings, cost savings, and/or enhanced convenience of travel by transit, whether real or perceived, compared to travel by private automobile. The net advantage that transit must have over the SOV varies by the type of worker. Commuters who have ready access to an SOV generally need to sense a greater difference between transit and SOV quality of service than those whose choices are more limited. If the setting does not result in transit being competitive, transit may need to be "helped" along by implementation of one or more supporting strategies.

Some particular examples of transit services and environments which lend themselves to consideration in a suburban situation are as follows:

Reverse Commuting

Many suburban employers are finding it difficult to fill low- and mid-level positions because they are located in areas where the people who often fill these positions cannot afford to live. At the same time, many inner-city residents are unemployed because they have no access to such jobs. Many public transit systems provide *reverse commute* service (AM outbound, PM inbound), but such service tends to be relatively low quality because the system's primary interest is in getting the vehicle back to the suburban end of the line to make another trip in the primary commuting direction. Also, many suburban jobs are located in office parks which are not easily accessible from existing transit lines.

Reverse commute service consists of improvements to existing lines (increased frequency, route changes) or new services. New services can be operated by the existing public transit agency or contracted to a private operator, or can be organized by the employer (or group of employers) as a buspool or subscription bus service targeted to selected employment and/or residential areas. A special circumstance which favors reverse commute service is when an employer relocates from a central city to a suburban location. This occurred in the case of the National Geographic Society, which started a buspool operation to transport Washington, D.C. residents to a relocated facility in the Maryland suburbs.

Suburban Route Restructuring

A major difficulty in using transit to get to suburban workplaces is that they tend to be widely scattered around the periphery of the central city, while in many cities the transit routes are focused primarily on radial corridors heading into the central city. Thus, even when suburban job sites are accessible via transit, making the trip often requires suburban residents to travel into the central city, transfer routes, and use another line to get back out to the suburban work site. Such trip patterns tend to magnify the disadvantage of using transit, because driving one's own SOV is considerably more direct and faster. The solution is to update the route structure to more closely match current suburb-to-suburb travel patterns and minimize the number of transfers. The challenge is to do this in a way that is both cost-effective and not unduly harmful to existing riders.

The City of Bellevue, Washington did this by restructuring some of its bus routes to provide more direct connections between suburban residential and employment locations. This was part of a major transit improvement program that included new services, sub-regional transit centers, park-and-ride lots, a downtown circulator, and an aggressive marketing effort. At the same time, Bellevue changed its zoning rules to provide for increased density downtown, reduced parking ratios, and more pedestrian- (and rider-) friendly street design. By recognizing and accommodating the distinctive nature of suburban Bellevue, this program has a good prognosis for success.

If restructuring routes is not feasible, it may be possible to implement a *timed transfer* system. This is used mainly in small- and medium-sized systems in which a relatively large number of riders need to transfer. The schedules of the various routes are coordinated so that many (or all) of the buses arrive at a central location at the same time, and lay over until all transfers are successfully completed. This strategy is less costly than providing direct service, and by minimizing the time and inconvenience associated with transferring, may be quite acceptable to riders.

Shuttle Connections

A key feature of most suburban office parks is that they are not in pedestrian-friendly environments. Either they are located too far from other activities (such as shopping) or there is a lack of sidewalks and other amenities that facilitate walking. Some potential transit users undoubtedly drive to work because they need their SOV for running errands during the day or going to lunch. Using short (1-5 mile) shuttle routes with small buses to connect isolated office buildings with retail and other services can enable such employees to use transit for their travel to and from work. This is the same concept behind downtown shuttle bus systems, which often use buses which look like trolley cars and have a nominal or free fare.

In many suburban areas served by rapid or commuter rail lines, nearby employment is often located too far from the rail station to access by walking. If there is any nearby bus service at all, it is usually designed to feed passengers to the rail station in the morning and from it in the evening. Implementing new bus routes or restructuring existing ones can link stations with suburban jobs, thus allowing both "inbound" and "outbound" workers to use the rail system for commuting to the suburbs.

Buspools/Express Bus Service

Many of the more successful buspool programs serve employers that are geographically isolated or otherwise very far (more than 50 miles) from where their employees live. In some cases, a substantial physical barrier (lake, river, etc.) separates people from their jobs. Such situations often lend themselves to express bus service or buspool programs because the long travel distance or the need to cross a "choke point," such as a bridge, magnifies the inconvenience associated with driving. Also, long bus routes spend a proportionately smaller amount of time collecting and distributing riders, resulting in transit having little, if any, travel time advantage.

COM-BUS of Southern California is an example of a long-haul buspool serving suburban employment centers. The workplaces are the large aerospace companies, which tend to be clustered in one part of the Los Angeles region. Luxury over-the-road buses are used and the one-way trip lengths vary from 20 to 70 miles. Riders subscribe on a weekly basis. Pick-up and drop-off times are minimized. After service was initiated, ridership stabilized at 2,000 employees using 47 one-trip routes. The system is estimated to serve a high percentage of the long trips (over 20 miles) to the areas served. (FHWA, *Traveler Response Handbook*, 1981.)

TRAFFIC CONDITIONS

Traffic congestion has a mixed effect on transit operations. On one hand, more congestion makes driving one's automobile more difficult and time-consuming, thus reducing the attractiveness of driving alone. On the other hand, congestion also tends to reduce bus running times (as well as on-time performance), making it difficult for buses to achieve a travel time advantage. Transit services operating on their own guideway do benefit from street congestion, though, since this increases the relative time savings for such services.

SUPPORTING STRATEGIES

As noted above, transit's ability to attract choice riders is largely a function of its time and cost advantages for each commuter. Because the time and cost differences between transit and private automobile are sometimes subtle and often difficult to perceive, transit strongly benefits from a variety of supportive actions that magnify its advantages. There are also supportive actions which do not directly affect time or cost, but which decrease the perceived inconvenience of using transit.

These strategies are very important adjuncts to successful transit service implementation. The success of any new or improved transit service is often directly related to the quality of these supportive actions. Examples of these actions include:

- <u>HOV Facilities</u>: special lanes or roadways on freeways or arterials, or a transit "mall" in the downtown area that reduces transit vehicle running time;
- <u>Parking Pricing</u>: parking taxes or surcharges are especially effective in creating a cost differential between driving and transit and encouraging a driver to seek alternatives to driving;

- Parking Limitations: zoning or similar restrictions that limit the number of parking spaces have the primary effect of increasing the inconvenience associated with driving (i.e., finding a space or being faced with high parking costs);

- Fare Subsidies: subsidizing transit fares can help get new services established and subsidies can be targeted at certain groups to help overcome an initial reluctance to use transit;

- Convenient Payment: fare passes and other pre-payment methods remove a major inconvenience to using transit, encourage regular ridership, and can be selectively (and discreetly) subsidized;

- Information Services: using transit requires information on routes, schedules, and fares that non-transit users often find difficult to obtain and understand; providing such details conveniently through a workplace kiosk removes yet another impediment to using transit, particularly if the kiosk is staffed with knowledgeable people;

- Site Design: many suburban employment centers have not been designed to accommodate transit vehicles easily, resulting in a long walk and an isolated wait at a bus stop on the main road. Relatively minor changes in site design guidelines can greatly improve the convenience and reduce the time associated with using transit;

- Park-and-Ride Lots: these are a way of effectively extending transit's service area by providing a convenient transfer point. Park-and-ride lots allow transit routes to be concentrated, thus offering more frequent service than trying to cover a low-density area with the same number of routes;

- Guaranteed Ride Home: for areas with limited hours of service (e.g., buses departing 4 - 6 pm only), a guarantee of a free or subsidized ride home (usually via taxi) can assure employees who occasionally must work late or who feel they might need to leave during midday (e.g., to attend end to family emergencies) that they will not be stranded at work;

- Mid-day Shuttles: a commonly given reason for not using transit is that a personal vehicle is needed for running errands during the day. Providing a shuttle bus to connect an isolated office park with nearby merchants and services allows employees to use transit to get to work without feeling "stuck" in the middle of the day.

1.4 EXAMPLES

Because the successful implementation of transit serving suburban activity centers is still a relatively rare phenomenon, there are only limited references to the topic in the literature. Some of the more pointed examples date from the mid-1970's, when a variety of actions were taken in response to the "gas crisis" of 1973-1974. Invariably, though, the more successful programs are those in which one or more supportive actions ("carrots") and/or disincentives ("sticks") exist to enhance the relative competitiveness of transit.

1.4.1 First Hill Express Services

This is an example of a new express service being provided to a congested suburban activity center, accompanied by a variety of supportive actions which made transit easier to use.

The First Hill area, a 4.5 square mile activity center just outside of downtown Seattle, has seven medical institutions, one university, and several medical office buildings and support clinics that employ a total of 14,600 commuters. While parking in the area was quite limited, transit ridership was low, attributed largely to the poor quality of transit service (passengers had to transfer in downtown Seattle and thus faced a long trip time).

In 1988, Seattle Metro initiated special express service for First Hill employers. This consisted of express transit service from each of six park-and-ride lots to the hospitals and university. Travel time from the parking lots to the hospitals and university range from 24 to 35 minutes, depending upon which lot is used. Service operates on a 30-minute headway during peak hours (as defined by the start and stop times for the first shift).

Employers purchase a set minimum number of passes each month (based on the necessary system minimum pass sales and the employers portion of total area employees). The employers then resell the passes to their employees, at a discount if they so choose.

Mid-day and evening back-up service is provided under contract with a taxi operator. Each employer determines how it will define and limit emergency taxi utilization, as well as determining what portion of the taxi charges to pass on to the employee. Additionally, First Hill passes can be used on any other Metro bus service.

The First Hill Express Service has increased transit ridership among the participating employers by as much as 75 percent.

Swedish Hospital Medical Center is one of the participating employers. This hospital was one of the leaders in implementing actions to support transit and carpool use. These actions included:

- Designating a full-time Transportation Coordinator to manage employee transportation benefits.
- Increasing the price of drive-alone parking from $5/month to $22/month and later to $50/month.
- Severely limiting the number of parking spaces for day shift employees.
- Increasing the transit pass subsidy from $5-$10 to $15 per month.
- Supporting a new express transit service through guaranteed transit pass allocations.
- Contracting with a local taxi company to provide a guaranteed ride home for late workers.

In 1988, prior to this program, the day shift drive-alone rate for Swedish Hospital was 59 percent. As of late 1990, this had been reduced to 41 percent.

1.4.2 Downtown Orlando Intercept Park-and-Ride

This is an example of the use of park-and-ride facilities and a shuttle bus service to intercept commuter autos destined for the central business district (CBD).

The City of Orlando, Florida, implemented a downtown park-and-ride shuttle transit system as part of a comprehensive transportation system management program. The major objectives of this program were to reduce daily parking demand and hence improve air quality and traffic flow in downtown Orlando.

Orlando is at the heart of one of the fastest growing metropolitan areas in the country. In 1982, the city implemented a comprehensive program aimed at improving peak-hour traffic conditions in the CBD and on the arterial streets leading to the CBD. One of the more innovative aspects of this program was the new park-and-ride/shuttle transit system, called the "Meter Eater", intended to encourage commuters to park just outside the CBD.

One of the transit routes provided peak-period service connecting publicly owned parking facilities adjacent to the CBD with large employment sites inside the CBD. Another route circulated among the major downtown generators during the middle of the day. Small buses designed to look like trolley cars were used. The fare was set at 25 cents, but was free to purchasers of a monthly parking pass. The major CBD employers were encouraged to partially subsidize the parking/shuttle bus cost for their employees. Service began in February 1982, with an initial ridership of 60 persons per day.

Extensive promotion and new free mid-day service increased daily ridership to 660 by 1983. In 1984, mid-day service was extended to cover nearby senior citizen high-rise buildings and a "Meter Eater Club" was established. Persons purchasing the monthly Meter Eater pass receive discounts at participating downtown merchants. By 1984, ridership was over 750 per day and the service was operating at a revenue/cost ratio of about 40 percent. The operating expenses are about $25 per vehicle-hour (1984 dollars) or $850 per day for the four-bus service.

1.4.3 Orange County Site Design Guidelines

This is an example of a transit operator's effort to create site design guidelines so that future suburban developments can readily accommodate transit services.

Orange County, California is a large and rapidly growing suburban area south of Los Angeles. In recent years, accelerated growth has outpaced the area's ability to provide new roadway capacity, and the result has been substantial congestion in what once was a low-density suburban environment. The County is quickly becoming a high-density suburban environment, with much of the office and retail growth occurring in major activity centers such as South Coast Metro. The Orange County Transit District (OCTD) is at the forefront of transit agencies struggling to meet the needs of sprawling suburban growth patterns. Among its forward-thinking goals is a policy to increase the coordination of transit and land use planning. This includes various aspects of planning, such as the concentration of jobs, transit-sensitive street design, and parking policies which provide disincentives to SOV use.

As part of this program OCTD is working with private developers in the early planning stages of future shopping malls, office parks, and other developments. One particular aspect of this program is a set of guidelines for making new office parks and shopping centers more "transit friendly". These are described in a report entitled Design Guidelines for Bus Facilities, Orange County Transit District, 1990, which is made available to site developers. This report provides additional detail and design specifications for transit amenities, including:

- Planning site layouts with the major areas of activity located next to streets which currently have transit service. Physical barriers between the buildings and bus stops such as landscaped berms, noise barriers, and parking lots should be avoided.

- Provision of transit amenities such as bus shelters and benches at the bus stop, and information displays within the site's buildings.

- Provision of bus turnouts at the bus stops, if warranted by surrounding roadway conditions. If the passenger volumes are high enough, provision of an off-street bus terminal or layover area.

This program was implemented in November 1988, and to date no results have been documented.

1.4.4 Greater Valley Forge Suburban Services

This is an example of how a Transportation Management Association (TMA) worked with an existing transit agency to initiate new and expanded transit services in a suburban environment.

Over the past two decades, the King of Prussia area has grown from a remote suburb of Philadelphia to one of the region's major employment centers. Roads which were once adequate to serve the needs of a sparsely populated community are becoming increasingly congested throughout the day. The area's employment growth, development, and investment has increased much more quickly than the capacity of surrounding roadways. Meeting all of the growth in travel demand by expanding highway capacity is not possible.

In order to address this situation, the Delaware Valley Regional Planning Commission (DVRPC) helped create the Greater Valley Forge Transportation Management Association (TMA). This organization is funded 50/50 by local townships and developers, with some additional funds for specific projects from State contracts. The TMA has an active agenda, including the promotion of ridesharing, development of an impact fee program, and a transit marketing agreement with SEPTA, the regional transit agency.

The Greater Valley Forge area is different from other suburban areas in that it enjoys a reasonably high level of transit service. However, much of that service was oriented towards suburban commuters headed into downtown Philadelphia, and was not of much help to employers in the Greater Valley Forge area. Still, the existing service provided a base to work from and the TMA has been active in helping to implement new transit services, including:

- New long-distance commuter bus service between Reading and Philadelphia (about 50 miles), with an intermediate stop at King of Prussia. PennDOT built one park-and-ride lot midway between Reading and King of Prussia and a private property owner built another.

- Expanded SEPTA service. Various kinds of services were created in response to employers' requests, including reverse commute bus service and shuttle buses to connect commuter rail stations with employment centers. Employers put up $160,000 in the first year to cover SEPTA's farebox deficit. Annual ridership went from 600,000 in the first year to 900,000 in the second year, reducing the annual subsidy requirement to $35,000.

1.4.5 Tyson's Corner/Fair Lakes Shuttles

These are two examples of shuttle bus systems that connect rail transit stations with suburban residential/workplace developments.

Tyson's II is a major concentration of suburban office and retail activities in McLean, Virginia, adjacent to the well-known Tyson's Corner shopping center. Since June 1986 a private bus operator, Transportation Management Service, has been operating 25-passenger shuttle buses between Tyson's II and the West Falls Church Metrorail station, about four miles away. Two buses shuttle residents to the station and employees from the station to the workplace in the morning, and the reverse in the evening. The service operates only weekdays, during morning and evening peak hours, at headways of 20 minutes.

As of September 1991, the service was carrying 300 passengers on an average weekday. In the morning peak period, about 46 percent of the ridership is to the rail station, and 54 percent is from the rail station. The operating cost is $1.29 per passenger, and a $0.50 fare is charged; thus the revenue/ cost ratio is 39 percent. Fairfax County pays the rest of the cost.

Fair Lakes is a growing office/residential/retail complex at the intersection of I-66 and US 50 in Fairfax, Virginia. Since 1988, Transportation Management Service has been operating a shuttle system between the development and the Vienna Metrorail station. This service operates weekdays from 6:30 to 9:00 a.m. and 4:00 to 7:00 p.m. on 30 minute headways. The system began with 16-passenger vans and now uses both vans and 25-passenger minibuses. There is no charge to use the service and the Fair Lakes developer, Hazel/Petersen, pays the entire cost and charges the cost back to the apartment and office buildings in the development.

As of September 1991 the system was carrying 240 riders per day, with 69 percent going or traveling to the rail station in the morning and 31 percent from the rail station. The contract to operate the service has recently been extended for another three years.

1.4.6 National Geographic Buspool

This is an example of one employer's initiative to implement a buspool program to retain employees who might be lost as a result of the employer's move to the suburbs.

Several years ago, the National Geographic Society decided to relocate its bindery plant from downtown Washington, D.C. to a location 20 miles away in the Maryland suburbs. Some of the Society's 1,200 affected employees did not have access to an automobile and others would have been greatly inconvenienced by the move. In order to minimize this problem, the Society contracted with a local private bus company to provide 11 routes, most of which serve reverse commuters. Daily ridership on the 8 routes from Washington was about 850 round trips, or about 35 percent of the workforce. The cost to the employee was $30/month (1974 dollars), with the Society covering the rest of the service's cost.

1.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

The ability of transit to compete with the automobile varies greatly with the conditions of its implementation. Several examples of the impacts of new transit service or service changes can be drawn from one compendium. (FHWA, *Traveler Response Handbook*, 1981.)

CHANGES IN EXPRESS BUS SERVICE

In most cases express bus service is offered in addition to pre-existing local service, and so it is difficult to isolate the effects of the express service by itself. However, the net increase in ridership after service is added can be estimated. In general, each 1 percent increase in express service frequency or route coverage (measured in bus trips or bus miles) has led to a 0.9 percent increase in ridership. (Note: this and subsequent elasticity measures reported in this section are based on the log arc definition). This means that ridership does not generally keep pace with service increases, perhaps indicating a "diminishing returns" effect of adding bus service. A value less than 1.0 indicates that increasing express transit service coverage cannot generally be expected to return a commensurate ridership increase on a percentage basis. Examples of service elasticity of 1.0 exist, but are rare, and usually involve express service operating on a separate guideway.

Of greater concern is the fact that when express service is implemented in an area already served by transit, some of the express riders are diverted from existing local routes. An examination of 15 express bus projects indicated that on average, 39 percent of the express riders had previously used a local bus, 46 percent had used a private automobile (37 percent as drivers, 9 percent as passengers), and 15 percent had used another mode or not made the trip. The local bus diversion ranged from 10 percent to 71 percent. Therefore, the effect of express transit service on reducing private vehicles travel must take into account the fact that many of the new riders do not come from private vehicles.

Seven specific cases of existing and planned express transit projects from around the country were analyzed as to their effect on vehicle miles of travel (VMT). On average, a reduction of 0.89 percent in regional work trip VMT was calculated, equivalent to a reduction of 0.31 percent in total regional VMT. The cost per VMT reduced ranged from $0.36 to $0.54 (1991 dollars) and the cost per one-way work trip reduced ranged from $2.15 to $3.24 (1991 dollars).

EXPRESS REVERSE COMMUTE SERVICE

Reverse commute service is a special case of adding express transit service to supplement existing local routes, which usually offer very poor morning service from urban areas to the suburbs. Studies in Washington, D.C. and Baltimore indicated that such service is fairly well utilized, to the extent that the routes connect areas of low-income housing with suburban jobs that are attractive to such residents. However, the vast majority of the users of the new services come from existing local routes; only about 18 percent were in private vehicles (9 percent drivers, 9 percent passengers). Thus, the major benefit of express reverse commute service is in providing enhanced mobility to lower-income workers, rather than in removing private vehicles from the road.

CHANGES IN LOCAL TRANSIT FREQUENCY OR COVERAGE

"Before and after" studies from around the country indicate that the elasticity of bus ridership with respect to frequency (buses per hour) is approximately 0.5. A greater response can be expected in areas having a large number of potential choice riders, where the original frequency is three buses per hour or less, or where the trips are fairly short. Research in the northeast United States suggests that the frequency elasticity of commuter rail riders is slightly higher: 0.6 to 0.7. As with express service improvements, some of the riders of improved local service come from other local routes. Surveys in Massachusetts provide the following breakdown of former modes: 80 percent private vehicle (68 percent drivers, 12 percent passengers), 15 percent other bus, 5 percent other. Research using travel demand models in Denver, Ft. Worth, and San Francisco has suggested that a regionwide 25 percent decrease in wait time (equivalent to a 33 percent increase in buses per hour) would result in a 0.3 percent to 2.0 percent reduction in regional work trip SOV VMT.

Similar analyses of changes in area-wide transit service coverage indicate that the overall elasticity of ridership with bus miles of service is 0.8. The values tend to be lower (around 0.6) for peak-period service and service oriented to the CBD. Regional analyses of four large and six smaller cities found that on average, in the large cities a 0.04 percent increase in bus miles resulted in a 0.13 percent reduction in VMT and in the smaller cities a 0.07 percent increase in bus miles resulted in a 0.03 percent reduction in VMT (in both cases, 1 bus-mile was assumed to be equivalent to 2 auto-miles).

BUSPOOLS

Buspools and subscription bus services are most often implemented as new services targeted at specific residences or workplaces, rather than extensions of existing service. Thus, it is not feasible to analyze their ridership in terms of elasticity. In fact, since buspools are usually highly customized services for each individual situation, there are few rules of any kind that can be used to estimate their impact. Some results can be drawn from the literature for two types of buspools: industrial and suburban long-haul.

INDUSTRIAL BUSPOOLS

An "industrial" buspool, in this context, is one that is oriented towards a specific employer. Most of the examples involve industrial sites with large concentrations of blue-collar workers. Table 1-3 shows the relevant data.

Three cases (Decatur, Flint, and Peoria) were subscription buspools designed to transport in-city workers to large industrial sites. All three have subsequently been discontinued. In Decatur and Flint, large amounts of unscheduled overtime made it difficult for workers to subscribe to a fixed-schedule service, and so the ridership needed to sustain service was not maintained. In Peoria, the service continued for five years until the private operator went out of business.

The Newport News example is unique. The Newport News Shipbuilding and Dry Dock Company is located on a peninsula in southeast Virginia. Its congested location, combined with a lack of parking and the aggressive pro-ridesharing policy of its management has resulted in one of the most successful industrial-based buspool/ transit programs in the country.

The Bremerton, St. Louis, Newport News, and Southern California programs are more successful than the other three. One distinguishing characteristic is that their average route lengths are much longer (20-70 miles) than the other three programs (14-16 miles). Longer buspool routes have two major advantages over shorter routes: 1) less passenger pick-up and distribution time, as a proportion of the entire route, and 2) greater commuter resistance to the alternative long drive by private SOV.

TABLE 1-3

SAMPLE BUSPOOL PROGRAMS

	Percent of Workers	Prior Mode of Buspool Users (Percent)			
Area	**Using Buspool**	**Driver**	**Passenger**	**Bus**	**Other**
Flint, MI	5*	59%	28	N/A	13
Decatur, IL	4	N/A	N/A	N/A	N/A
Peoria, IL	9	47	25	28	N/A
Bremerton, WA	11	N/A	N/A	N/A	N/A
St. Louis, MO	3	N/A	N/A	N/A	N/A
Newport News, VA	8	47*	38*	14*	1*
Southern California	5*	N/A	N/A	N/A	N/A

* Estimated

Source: *Traveler Response to Transportation System Changes*, Second Edition, Barton-Aschman Associates, R.H Pratt & Company, July 1981.

SUBURBAN LONG-HAUL BUSPOOLS

These are residential-based programs, targeted at residents of a particular community who work at a distant central location, usually a downtown. Two of the more successful examples are the Reston (Va.) Commuter Bus and the Columbia (Md.) commuter bus system. Both communities are "new towns" located about 25 miles from Washington, D.C. Both areas are relatively densely settled (compared to the surrounding areas) and had little employment when they were first built in the late 1960's and early 70's. The Reston system captures about 23 percent of the work trips destined to Washington, while the Columbia system serves 81 percent of the Washington trips.

1.6 COST EFFECTIVENESS

The cost effectiveness of transit in removing SOV's from the road is highly dependent on the details of the particular setting. However, a hypothetical example can be presented to provide a reasonable estimate of the figures involved.

The example scenario is a new express bus route serving a suburban office park. It is proposed to operate four trips on weekday mornings (and four in the evening), every half hour from 7:00 a.m. to 8:30 a.m., inclusive, from an existing park-and-ride lot to the office park. Two 40-seat buses will be used. The trip from the park-and-ride lot to the office park is 15 miles and takes 30 minutes, using limited-stop operation (the buses make only two stops after leaving the park-and-ride lot). The average commuter trip length is 15 miles each way (12 miles on the bus, and 3 miles to drive to the bus). Including deadhead time, operating the morning service requires 5 bus hours. The local transit agency will operate the service using existing buses at a cost of $80 per vehicle-hour ($400 for the morning period). The one-way fare is $1.25.

Table 1-4 summarizes the economic performance of this hypothetical service under different ridership levels. The cost effectiveness of any transit scenario is proportional to the service's ability to attract riders. This is most readily expressed as the *load factor,* which is the proportion of the available seats which are filled.

A typical transit mode share for suburban workplaces is about 1 percent. If it is assumed that this scenario achieves a transit share three times as large, this implies that the transit service must effectively serve an area containing 2,700 people who work at this site, in order to achieve a load factor of 50 percent. This of course presumes that the site even *has* 2,700 employees. It should also be noted that the buses would need to run full to achieve even a 50 percent farebox recovery ratio, which is considered acceptable by many transit agencies. A lower (and less costly) level of bus service might be considered in this case, but it would likely have a lower mode share as well.

From this analysis, it is clear that the cost (subsidy) per vehicle trip removed from the road varies considerably with the demand for the transit service. Assuming even a relatively large modal share for transit, the total commuter trip market must be fairly large for the hypothesized transit service to achieve a reasonable cost per vehicle removed. However, if enough riders use the service, transit service would result in a respectable cost per vehicle removed.

1.7 IMPLEMENTATION ISSUES

One of the crucial questions facing the start-up of any new or expanded transit service is the issue of who will operate the service. As a practical matter, service extensions are usually provided by the current public transit operating agency. New

TABLE 1-4

Economic Performance (Hypothetical Scenario)

Load Factor *(Percent)*	Morning Riders	Revenue Cost *(dollars)*	Auto Trips Removed	Subsidy *(dollars)*	Subsidy per Auto Trip Removed *(dollars)*	Subsidy per Net VMT Removed *(dollars)*
10	168	0.05	15	380	25.33	6.33
25	40	0.13	37	350	9.46	1.08
50	80	0.25	74	300	4.05	0.39
75	120	0.38	111	250	2.25	0.21
100	160	0.50	148	200	1.35	0.12
125	200	0.63	185	150	0.81	0.07

1 Assumes an initial vehicle occupancy of 1.08, and that 100% of the riders were previously either drivers or passengers.

2 Average of 10 standees per trip, which is normally considered unacceptable for express service.

3 Net VMT reduction = bus VMT + Private Vehicle VMT to park-and-ride lot less VMT from Private Vehicle trips removed, assuming that all riders must use a Private Vehicle to access the bus service.

routes can be operated either by a public agency or a private operator. In both cases, the potential operator will be skeptical about implementing any new routes or service improvements that are not accompanied by clear indicators of success. It is often necessary to secure additional subsidies from local governments or private developers or landowners, at least for an initial start-up period, until new ridership can stabilize.

Sometimes, a public transit agency can be persuaded to operate new service from within its current operating budget, if the route's potential is great enough. More often, though, some form of external subsidy is required. Or, it might be possible to contract with the agency to provide vehicles and operators for a fixed cost per hour (which clearly requires an external funding source). In many cases, the public agency's marginal cost of providing additional peak service is very high, and so the cost can be discouragingly high to start new service. Also, public agencies are subject to numerous regulatory requirements that tend to make negotiations cumbersome. (In fact, local or State regulations may need to be changed in some locales in order to allow innovative transit options to be pursued.) It may be more feasible to deal directly with a private transit operator such as a charter bus company. Private operators are usually less expensive and can implement service more quickly, but this sometimes involves a tradeoff of business stability, equipment quality, and other "short cuts" that such companies have been known to take.

A commonly used guideline in implementing transit service in an environment of uncertain demand (which is usually the case) is to proceed incrementally. The extreme case is to start with a carpool program and when this becomes popular, switch to vanpools. Then, when still more capacity is needed, implement buspools. Finally, once a certain level of demand is clearly demonstrated, the local transit agency will find it feasible to operate regular, fixed-route service. Various demonstration projects around the country have shown that services which start small and respond quickly to changes in demand are more successful than large-scale start-up efforts.

As the section on "Supporting Strategies" (page 1-11) noted, there are numerous actions which either directly support transit use by helping to provide a time, cost, or convenience advantage, and other actions which indirectly help by removing real or perceived impediments to using transit. It is vital to implement at least some of these strategies along with any new or expanded transit service. For one reason or another, transit is not the preferred travel mode of most commuters, and it is usually necessary to "stack the deck" in favor of transit and/or against driving alone, in order to have any chance of successfully inducing commuters to shift from the latter to the former.

For example, transit clearly benefits when it can achieve time savings over driving alone, as noted above. The operating speed of transit vehicles is a function of the number of stops made and the speed of surrounding traffic. For buses operating in mixed traffic, reducing the number of stops (i.e., express or limited-stop operation) enables the bus to travel almost as fast as private vehicles on the same road. Additional speed can be achieved by implementing a bus signal preemption system, which minimizes the number of signal stops for buses. The only way for transit to achieve true time savings compared to private vehicles on congested facilities, though, is for the transit vehicles to operate on their own right-of-way. This includes buses operating on their own guideway, a reserved freeway lane, a reserved arterial lane, or using a toll or queue bypass facility. It also refers to all forms of rapid rail and commuter rail operations, and light rail lines that do not operate in mixed traffic. (See the Section-II B-2, on Preferential HOV Facilities for more information on potential time savings.)

Access/wait time savings can be achieved only by extending the coverage of service to reduce walk times or by reducing the intervals between transit vehicles in order to decrease wait times. Both of these can be considerably more expensive to achieve than reducing ride time, but as noted above, a minute of access/wait time savings is 2.5 times more beneficial than a minute of ride time savings. In particular, the need to transfer to complete a trip (and the time associated with that transfer) is viewed as particularly onerous by travelers. Some potentially less expensive ways of achieving access/wait time savings are:

- Restructuring routes to provide more direct origin-to-destination service (eliminates need to transfer and time spent waiting for second vehicle);

- Instituting a timed transfer system (minimizes time spent waiting for the second vehicle, when transferring is unavoidable);

- Extending park-and-ride service (in low density areas, it may be better to have commuters drive to a park-and-ride lot from which buses operate every 10 minutes, rather than provide walk access on a route that operates every 30 minutes); and

- Making modest bus route extensions at the workplace end (i.e., move the bus stop closer to the building).

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A.2 CARPOOL PROGRAMS

2.1 DESCRIPTION OF STRATEGY

Carpooling is the sharing of rides in a private vehicle among two or more individuals. Vanpooling is a similar sharing of rides, but involves a different type of vehicle (van rather than sedan) and seven or more occupants (see Section II A.3 for a discussion of vanpooling). Carpooling is the most prevalent type of alternative to driving alone. In 1980, 19 percent of all work trips were made by carpooling in the United States ("*Commuting in America: Executive Summary*," ENO Foundation, Transportation, Inc., 1987). In 1990, the share of carpools among work trips in the Los Angeles region was 14 percent ("*The State of the Commute: Research Findings*," Commuter Transportation Services (CTS), 1991).

The process of grouping commuters into carpool arrangements, or carpool matching, occurs in one of three ways:

- *Area-wide Programs:* Public agencies and non-profit organizations, operating in most urban areas, promote carpooling via roadside signs, media campaigns, and employer outreach programs. Many of these programs were created in response to the 1973 oil crisis. Employees and commuters can call into the agency to receive "instant" matching over the phone or complete a carpool registration form and be sent a "match list" with the names of others that have similar commute patterns. These organizations maintain computerized databases with the names of potential carpools and this is used to make matches.

- *Employer and Developer Programs:* The 1979 oil crisis prompted the Federal sponsors of rideshare programs to modify carpooling efforts in urban areas to focus on employers as the means to promote carpooling. While carpool programs at large employers had been in existence since before War II, the limited effectiveness of areawide promotion alone prompted rideshare agencies to begin marketing carpooling through employers ("*Employer Involvement in the Worktrip; A Trend Towards Employer Associations,*" Schreffler, Eric N., Massachusetts Institute of Technology, Working Paper 83-1, January 1983). In the mid-1980's, carpool programs sponsored by commercial and residential developers, for tenants and homeowners, were initiated in response to traffic mitigation requirements, ("*Evaluation of Transportation Management Plans in Residential Developments,*" Wolf, Christine; Ulberg, Cy, Paper 910405 before the 70th Annual Meeting of the Transportation Research Board (TRB), 1991).

- *Informal Arrangements:* While many commuters are placed into carpools via employer or areawide promotional programs, the majority of commuters form carpools through more informal arrangements. According to a 1991 survey of commuters in Southern California, 53 percent of carpoolers in the region share a ride with household members, 6 percent with other relatives, 15 percent with friends and neighbors and less than a third with co-workers. Among the co-workers, one-quarter used a match list from the employer or areawide program and three-quarters formed a carpool without a match list. Similarly, one-quarter of those who carpool with neighbors do so as the result of obtaining a match list. ("*The State of the Commute: Research Findings,*" Commuter Transportation Services, Inc., 1991.) Another phenomenon is called "casual" or "instant" carpooling, whereby individuals form ad hoc arrangements to benefit from the time or toll savings afforded by use of an HOV lane on a freeway or bridge and tunnel approach ("*Evaluation of Springfield Instant Carpooling,*" Reno, Arlee; Gellert, William; Verzosa, Alex, Urban Institute, Paper before the 68th Annual Meeting of the Transportation Research Board, 1989).

The matching process itself involves a variety of techniques from highly sophisticated computerized matching systems to informal arrangements between two people, independent of the intervention of a third-party "broker." Matching systems that are sensitive to specific origins, destinations, schedules, travel routes, and passenger preferences (smoking, etc.) are perhaps the most effective at making good matches, but the more and finer the characteristics that need to be matched, the smaller the number of potential matches possible.

2.2 NATURE OF EFFECTIVENESS

Carpooling implicitly acknowledges the convenience afforded by private passenger vehicles, and simply attempts to increase the efficiency of the transportation system by carrying commuters and others in fewer vehicles. Carpooling requires that similar origins (home-end), destinations (work or school) and schedules (work or school start times) be coordinated so as to find a "match." Having a sufficiently large pool of commuters in a matching database is required to find good matches for those requesting shared ride arrangements. Organized carpool programs targeted to commuters at their employment site seem to be more effective than those targeted at residential areas (home-end) or schools.

Carpooling does present disadvantages when compared to driving alone. Carpooling requires that set schedules be maintained on ridesharing days. Carpoolers are more constrained in their ability to run errands before, after, and during work. If carpoolers meet at a common point or the passenger(s) are picked up, some travel circuity is experienced, thus increasing commute time. Finally, while many individuals enjoy the personal interaction inherent in sharing a ride, others find carpooling deprives them of time alone.

Why, then, do employees or students carpool? Some commuters have no automobile available to them for commuting purposes and thus carpool or use transit to get to and from work. In addition to appealing to those who have limited availability of a private vehicle, carpooling has been promoted as providing cost savings to commuters by splitting the cost of driving. These costs can be substantial, especially when both the perceived out-of-pocket and the full cost of commuting are taken into consideration. A 1989 survey of commuters in Southwestern Connecticut showed that among carpoolers polled, the top three features that they viewed as a positive to carpooling were: saving money (30 percent), time to relax (21 percent), and socializing (21 percent) ("*Southwestern Connecticut Commuter Transportation Study: An Analysis of Commuter Attitudes and Practices,*" Angell, C.D. and Ercolano, J.M.; Metropool and SACIA, Paper 910418 before the 70th Annual Meeting of the Transportation Research Board, 1991). The existence of incentives (preferential parking), disincentives (parking charges) or carpool subsidies are perhaps the greatest form of inducement. These supporting strategies are discussed below and in separate sections on Parking Management (Section II B.4) and Transit/Ridesharing Incentives (Section II B.3).

Finally, rideshare planners, in an attempt to induce a greater proportion of commuters into carpooling, are promoting "occasional" or "part-time" carpooling. While the overall travel benefits are greatest when carpools operate five days a week, a far greater proportion of commuters can carpool on a one- or two-day-a-week basis. This allows people to run errands or perform business using their cars on most days, but enables them to carpool at least on a part-time basis. In Southern California, a recent survey revealed that 6.5 percent of those people who usually drive alone to work (3 or more days a week) use an alternative one or two days per week ("*The State of the Commute: Research Findings,*" Commuter Transportation Services, 1991).

2.3 APPLICATION SETTING

Carpooling seems to work best as a TDM strategy under the following conditions:

TRAVEL MARKETS

Commuters traveling to and from work during the peak travel periods seem to be the best market for carpooling given the fact that the largest pool of potential ridesharers is derived under these conditions. Remember, however, that the work trip only accounts for one-quarter to one-third of all trips in an urban area and that organized carpool programs (areawide or employer-based) only account for one-third of all commuters that are sharing a ride. As mentioned earlier, while the majority of carpools are formed among household members and neighbors, organized carpool programs seem to be more effective at the work-end rather than at the home-end. Much of this is related to difficulties with marketing to households and matching among the lower residential densities as compared with employment sites.

The propensity of family members and neighbors to carpool is revealed in the case of a computer manufacturer in Orange County, CA. Two sites, both of a similar size and suburban location, exhibited very different ridesharing rates -- 10 percent at one site and 19 percent at another (as compared to 6 percent county-wide). The reason for the higher rate was that the site was a manufacturing location (with a high proportion of laborers) that employed family members living in the same geographic area. The other site was the corporate headquarters (with a high proportion of professionals and no subsidized cafeteria on-site) ("*AQMD Regulation XV Trip Reduction Plan: AST Research, Inc. Corporation Plan*," Harold Katz & Associates, December 1988).

Among work trips, carpooling is perhaps best suited to the suburban employment market. Since a growing proportion of work trips are characterized as suburban-to-suburban, carpooling is perhaps the most likely alternative to driving alone given the higher densities needed for transit and even vanpool options.

Carpool markets are further defined by the length of the work trip. Commutes in the 15- to 25-mile range seem to attract the highest proportion of carpools. The 1991 Southern California survey found that all commuters traveled an average distance of 16.6 miles and commuters who carpooled traveled an average distance of 18.7 miles. ("*The State of the Commute: Research Findings*," Commuter Transportation Services, 1991.)

Another market for carpooling is educational and recreational trips. Carpooling among school trips is often prevalent, given that much of them involves parents driving children to school. However, at secondary and higher education institutions, carpooling among students is largely due to lower private vehicle availability and greater parking constraints than is the case at workplaces. A significant number of universities have formal carpool and commute alternative programs that market directly to students. At the University of Maryland, a 1982 study reports that 30 percent of all students carpool, while only 10 percent of faculty and staff share a ride. It should be noted, however, that students are offered both ride matching services and preferential parking on campus. ("*Ridesharing Programs at Educational Facilities*," Dingle Associates, Inc., prepared for US Department of Transportation, Federal Highway Administration, 1982.)

TRAFFIC CONDITIONS

Carpooling may be promoted most aggressively by areawide agencies and employers in areas with the most severe traffic congestion and concomitant air quality problems. The existence of congestion, however, is not a perceived inducement to carpooling among commuters. In fact, an analysis of 1980 census data showed that carpooling rates are higher in smaller metropolitan areas, due in part to the absence of good transit, but also perhaps due to the fact that these areas typically have less acute congestion and less dispersed travel patterns. These "simpler" commutes may thus lend themselves more to carpooling. ("*Commuting in America: Executive Summary,*" ENO Foundation for Transportation, Inc., 1987.)

While some commuters carpool to avoid the "hassle" and stress of driving in highly congested conditions (prevalent in larger urban areas), carpools do not inherently provide an advantage over driving alone in congested areas. Quite the contrary, when carpooling involves added travel time to pick-up riders, the carpool is placed at a distinct disadvantage to driving alone. Only when supporting strategies (see below) are in place to give a time advantage back to carpools or provide incentives to carpooling can the disadvantages of carpooling in congested areas be overcome.

SUPPORTING STRATEGIES

While organized carpool programs are generally based on ride matching and marketing efforts to educate commuters about the advantages of carpooling, these programs are most effective when supported with strategies that "equalize" the commuting equation to make carpooling more attractive and/or driving alone less so. These strategies, discussed in other sections, include:

- *High Occupancy Vehicle (HOV) Facilities* that provide a time savings to multi-occupant vehicles (see Section II B.2);
- *Preferential Parking* for carpoolers offering a walking time savings and affording the carpooler with a "perk" or simply the availability of parking for carpoolers while unavailable to solo drivers (see Section II B.4);
- *On-site Coordinator* at the employment site to work one-on-one with commuters to provide assistance in forming and maintaining rideshare arrangements (see Section II B.1);
- *Guaranteed Ride Home* programs to provide another supporting strategy by offering a back-up ride to carpoolers who either miss their ride or need to attend to a mid-day emergency (see Section II B.1);

- *Carpool Subsidies* to maximize the cost savings realized by carpoolers by sharing a ride; (see Section II B.3) and,

- *Parking Pricing* to provide a disincentive to solo drivers and an advantage to carpoolers (see Section II B.4). A hybrid of the carpool subsidy and parking pricing schemes is the travel allowance whereby employees are provided with a monthly stipend for commuting that can be used to purchase a parking place, a transit pass, or share in a parking space with another employee (carpool) (see Section II B.3) ("*A Review of Transportation Allowance Programs,*" Bhatt, Kiran, K.T. Analytics, Inc., Paper 910621 before the 70th Annual Meeting of the Transportation Research Board, 1991).

2.4 EXAMPLES

Examples of carpool programs are quite abundant but suffer from several distinct problems. First, evaluations of areawide programs are often dated and do not include "bottom-line" impacts. Rather, these examples document the number of commuters or employees contacted and match lists produced, not necessarily the number of people carpooling as a result of the program or a comparison of their services to other cost effective methods for inducing carpooling. Second, the programs never operate in a vacuum. For example, employees are often influenced by both employer programs and the media campaigns of areawide programs. Additionally, matching and promotion alone are seldom offered. Commuters are influenced by other strategies (parking) and external factors (fuel prices).

Brief examples are provided below for an areawide, employer- and developer-sponsored program. The reader is cautioned to remember that the examples involve both carpool promotional elements and other incentives that work as a package to affect the number of commuters choosing to carpool. Thus, the results reported here do not distinguish the impacts of carpool promotion alone, but rather report the impacts of "carpool" intensive programs that include promotion and incentives. Part III discusses the impacts of packages of strategies. References for the examples are provided at the end.

2.4.1 Area-wide - Commuter Transportation Services, Inc.

Commuter Transportation Services, Inc. (CTS) is located in Los Angeles, California and has a stated mission of improving commuter mobility. Principal stated benefits of CTS's work include relieving traffic congestion, improving commuter access to employment, improving air quality and conserving energy. Commuter Transportation Services (also once known as Commuter Computer) is a private non-profit company founded in 1974, funded primarily by federal, state and county sources. Important contributions are also made by the City of Los Angeles, some of its 1,800 businesses and over 3,600 worksites served.

Employee transportation and commuter matching services are offered as a public service. CTS works through employers and designated company coordinators to promote ridesharing among employees. CTS also assists "unaffiliated" commuters via an on-line telephone matching system. The organization provides match lists to employees, "master" lists to coordinators, and processes commute data into commute management plans for each primary employer client. CTS also provides employers and commuters with transit information and vanpool vendor information.

Approximately 250,000 commuters are registered with CTS. The agency reports that over 120,000 commuters are currently sharing rides as a result of registering with CTS or through contact with other ridesharers who have been served by CTS. Assuming that some three million commuters travel every day in the region, and 14.5 percent carpool or vanpool (1990), then CTS claims responsibility for 120,000 of the 435,000 daily ridesharers, or 28 percent of those sharing a ride. However, it should be remembered that many of these carpoolers are also responding to programs and information provided by their employer; this statistic should be viewed in light of both the employer and CTS's influence on ridesharing.

CTS estimates that nearly 340,000 individuals have been placed into ridesharing arrangements by CTS since its inception. Ridesharers have saved more than $800 million in transportation expenses, prevented over 80,000 tons of air pollutants from being produced, reduced over 2.8 billion vehicle miles during peak commute hours, and conserved more than 155 million gallons of gas. In 1989, CTS reported an annual vehicle miles traveled (VMT) reduction of roughly 500 million miles. This translates to approximately two million miles per weekday against a regional total of almost 250 million miles, or less than one percent. However, since work trips comprise only one-quarter of total VMT, CTS's impact on commuting VMT is more significant.

One means of estimating the effectiveness of CTS's carpool matching, promotion and employer outreach program is to compare the carpooling rate and mode split for firms that CTS assists with the carpooling rate and mode split for their entire service area. As shown in Table 2-1, employees who work for firms assisted by CTS commute at a vehicle trip rate of 78.8, meaning that just less than 79 vehicles are needed to transport each 100 commuters. By way of a comparison, commuters throughout the region require 87.5 vehicles per 100 commuters, resulting in a 10 percent trip reduction among firms working with CTS.

Again, one should remember that the impacts reported in Table 2-1, in terms of ridesharing activity and trip reductions are based on CTS's comprehensive programs, not just their carpool matching services. The overall results include the influences of those other services and the in-house programs and incentives of their client employers. Additionally, CTS serves many large firms and sites in downtown Los Angeles, which may contribute to a larger pool of carpool matches and access to public transit.

TABLE 2-1

Comparison of CTS Client and Regional Mode Split

Mode	CTS Client Employees (1987) Percent	Area Commuters (1988) Percent
Drive Alone	72	83
Carpool	6	11
Vanpool	>1	>1
Bicycle/Walk	1	3
Motorcycle	1	1
Public Bus	8	2
Private Bus	>1	>1
Other	1	>1
Vehicle Trip Rate*	**78.8**	**87.5**

* Number of vehicle trips to transport 100 travelers.

2.4.2 Individual Employer Programs - City of Pasadena

The City of Pasadena started its TDM program in 1989 in response to a regional air quality regulation (Regulation XV) that requires employers to reduce vehicle trips to employment sites. The City developed its comprehensive program as a model for other city employers (given a city ordinance requiring developer programs) and to offer commuter benefits to all employees using alternative commute modes.

The City employs 2,100 people, 1,700 of which are currently eligible for the TDM incentives program (the 400 non-eligible employees are in a union that has not reached agreement with the City on the TDM program or are non-management, non-represented employees). Nearly 500 of the City's employees work at City Hall, located in downtown Pasadena, a site relatively well served by transit and accessible to many restaurants and other personal services within walking distance.

The City's TDM program includes a drive-alone **disincentive**, parking fees, but also many **incentives** to employees to carpool. Elements of the program that influence carpooling include:

- Reduced parking cost of $10 per month for 2-person carpools and free parking for 3+ person carpools and vanpools as compared to $45 per month for SOVs,
- Transportation allowance of $20 per month given to all employees,
- Guaranteed ride home for ridesharers,
- On-site ridematching,
- $10 per month gasoline subsidy per carpool,
- 3+ person carpools may use city-owned vehicles for commuting, and
- Childcare subsidy ($40 per month) if **all** riders in carpool use childcare.

The TDM program is administered by a staff of one full-time coordinator and one part-time assistant in the Public Works and Transportation Department. An on-site information center provides access to program information. Staff also promote commute alternatives through transportation fairs, some direct mail, and new employee orientation. Parking fees and financial incentives are handled through payroll deductions and additions. Employees complete a one-time payroll deduction form, indicating their commute mode. Employees must complete a new form if they change to another mode.

The City has conducted two annual surveys, in 1989 (baseline) and 1990 (first year), for use in its Regulation XV plans. Between 1989 and 1990, SOV percentage decreased 30 percent, from 83 percent SOV to 58 percent at City Hall. All alternative modes showed increases with the carpool proportion more than doubling, from 12 to 27 percent. Given carpooling represented the greatest shift of workers from driving alone, and a majority of the total program elements involved carpool matching, promotion and direct financial incentives, it can be deduced that the carpool elements of the program were the most effective in inducing employees to shift to commute alternatives. City Hall's vehicle trip generation rate between 1989 and 1990 dropped from 87.4 trips per 100 employees to 68.9, a decline of 22 percent. This drop represents a reduction of 90 trips at the site during the year, from 414 vehicle trips to 324 trips.

Table 2-2 also shows how the shifts in various commute modes and the vehicle trip rate for City Hall compared with the other Pasadena employers in 1990. City Hall's SOV rate of 58 percent was 23 percent lower than the 75 percent average rate for all Pasadena employers. Its vehicle trip rate was 16 percent lower than the average rate for all Pasadena employers, representing a vehicle trip reduction of 63 trips.

TABLE 2-2

Comparison of Carpool Shares in Pasadena

Mode	City Hall 1989	City Hall 1990	City-Wide 1990
Drive Alone	83%	58%	76%
Carpool	12%	27%	15%
Vanpool	0%	2%	2%
Transit	3%	7%	4%
Other	2%	6%	3%
Vehicle Trip Rate*	87.4	68.9	82.3

* Number of vehicle trips to transport 100 travelers.

The promotion of carpooling and all other program elements and incentives were uniformly offered at all City work sites in the Civic Center, including the Central Library, Maintenance Yards, Police Headquarters and Water and Power Administration. The combined increase in Average Vehicle Ridership (AVR) (total employees divided by total private vehicle trips) was from 1.12 to 1.45 (toward a goal of 1.5). The City Hall occupancy increased from 1.1 to 1.34 based on the commute shifts described above. Other sites, however, namely the library and city yards increased from about 1.1 to 1.52 and 1.71, respectively. This was primarily accomplished by significant increases in carpooling.

2.4.3 Developer/Employment Center Programs - Hacienda Business Park Owners Association

Hacienda Business Park is located in Pleasanton, CA at the intersection of Interstates I-580 and I-680. Three million square feet of commercial and retail development have been built to date with another three to four million square feet planned. Almost 10,000 employees currently work in the business park, where the largest tenant is AT&T with nearly 3,000 employees.

The developers of Hacienda Business Park, Callahan-Pentz Properties and Prudential Insurance Companies of America, were required to implement a TDM program for land owners and tenants as part of the Planned Unit Development (PUD) requirements. They also committed to substantial roadway improvements. A goal was established of reducing the number of peak morning hour trips by 45 percent over hypothetical levels that assume all commuters travel between 7:30 - 8:30 a.m. in single occupant vehicles. Subsequent phases of development would be contingent on meeting this goal in a four-year time frame, and the requirement was later applied to all Pleasanton employers and building owners (of a certain size) via a city-wide ordinance.

The Hacienda Business Park Owners' Association (HBPOA) was established by the developers to oversee the operation and maintenance of the business park and assure compliance with the PUD requirements. Owners pay dues to the association to fund the transportation program. The HBPOA assists employers and owners in the park with developing and implementing their TDM programs, since the developer and employer must each comply with the ordinance. The HBPOA provides commute alternatives assistance to all employees within the park and reviews new building plans to assure they comply with city guidelines requiring that five percent of all parking be set aside and enforced as carpool and vanpool preferential spaces.

The HBPOA TDM program was initiated in April 1984 and originally consisted of two full-time staff persons overseeing services to tenants, building managers and employees. The program consisted of:

- on-site computerized carpool matching,
- new tenant orientation seminars,
- employee transportation coordinator (ETC) network, and
- transportation promotional fairs.

Additionally, a shuttle bus system that served a nearby BART (regional rail) station and provided lunch-time trips within the park was implemented by the Owner's Association.

The program has evolved since 1984 and currently involves carpool matching as provided by the regional ridesharing agency (RIDES for Bay Area Commuters), subsidizing transit passes on the BART Connection and the local transit system, assisting with employer and building-owner program planning, promoting the program through the HBPOA newsletter, preparing the annual report to the city for the business park, and coordinating the ETC network in the park.

In 1988, at approximately the end of the city's target period for achieving the 45 percent trip reduction, Hacienda Business Park had reached the goal, largely by shifting commuters out of the target hour, but also by inducing a number of employees to use commute alternatives, such as carpooling. A comparison of the drive alone and carpool share for Hacienda Business Park, in comparison to all employers within Pleasanton and two regional control sites (without a TDM requirement), reveals a significant reduction of trips. The carpooling share at Hacienda Business Park was 15.8 percent in 1988 compared to 10.8 percent for all Pleasanton employers and 4.7 - 6.9 percent at two control sites (other employment centers in Northern California). Applying vehicle trip rates to these cases, the HBPOA program reduced trips by 4 percent when compared to the city as a whole and by 8 percent as compared to other employment centers with no TDM program. Table 2-3 summarizes these findings.

Given that the bulk of the program was geared to carpool promotion, matching and preferential parking, the higher than average carpooling rates at the business park suggest the effectiveness of these strategies. The only other significant incentive was increased transit service and subsidies. However, transit usage to the Park actually declined from 3 percent in 1986 to 2 percent in 1988.

It should be noted that the effectiveness of the HBPOA program is largely driven by the largest employer, AT&T. If AT&T data were removed from the HBPOA analysis, the carpooling rate would be much closer to that experienced by the rest of the city. At the same time, AT&T owes much of its success to the HBPOA program. It seems unlikely that AT&T would have achieved its 1988 carpool share of almost 22 percent without the HBPOA program.

TABLE 2-3

Comparison of 1988 Carpool Shares at Hacienda Business Park

Method of Travel	Hacienda	Pleasanton City-wide	Walnut Creek	Santa Rosa
Drive Alone	78.7%	84.3%	89.9%	91.3%
Carpool	15.8%	10.8%	6.9%	4.7%
Vanpool	1.9%	0.7%	0.5%	0.1%
Transit	2.3%	1.6%	2.6%	1.4%
Other	2.5%	1.3%	0.1%	2.5%
Vehicle Trip Rate*	85.2	88.7	92.8	93.2

* Number of vehicle trips to transport 100 travelers.

2.4.4 Residential-Based Ridesharing - Germantown Share-A-Ride

In order to receive zoning approval to build 200 residential dwelling units in Germantown, Maryland, the developer had to meet County traffic alleviation requirements. Germantown is located in Montgomery County, Maryland, a northern suburb of Washington, DC. The developer elected to implement a **home-based** ridesharing program to meet these traffic reduction requirements. The ridesharing program was selected because it was 1) easy to expand, 2) broad-based, and 3) formed by the County so that future development rights would be easier to obtain. The County defined the service area to be served, and the program was implemented in May 1985.

The Germantown program provides free rideshare matching services to all individuals who live in the service area. Individuals request to be matched with others home-to-work trip matches theirs. The program obtains trip-related data on each requestor, including current mode of travel, and inputs these into a computerized database. Trip reduction impacts are generated by the computer program, based on the current travel mode.

A computer matching program then searches the existing membership to identify potential matches for each requestor based on home and work destinations. The requestor is then put in touch with potential matches, usually within a week of the requestor and match. It is up to the requestor and match to make their own arrangements and form a carpool. The program does call the requestor two weeks after the match is provided to check whether an arrangement has been made. (These calls are repeated every two weeks until the requestor makes contact with the match.)

Every six months each program participant is contacted by phose to determine which participants are still actively pooling. If no telephone response is received, a postage paid postcard is sent to the participant requesting information on current commuting modes. Participants that are no longer actively pooling and who do not have an interest in rejoining a pool, and participants who provide no response after both telephone and mail contact are dropped from the program rolls.

The program originally included extensive marketing as a County requirement. Marketing activities included regular mass mailings, radio ads, and display and classified ads in local papers. During the program's first two years, the program administrators met regularly with the County Planning Commission, the developer, and the advertising agency regarding marketing and advertising techniques. As of May 1991, the only marketing efforts are classified ads in local papers and mailings to new move-ins (averaging 200/250/month).

During the program's first two years, the developer was required to remove 100 vehicles or else face a $54,000 fine. At the end of the first two years, only 60-65 vehicles had been removed; but rather than impose the fine, the County increased the service area to include all nine sectors (approximately 19,000 households) of Germantown (the original service area was only five sectors) and gave the program another year to meet the 100 vehicle goal. This goals was met six months into the program's third year, at which point the marketing activities were terminated.

Since the program began in 1985, 1,700 individuals have applied to the program. As of May 1991 there were 570 active participants of which 327 were in ridesharing arrangements. These 327 were distributed among the available modes as follows:

- Carpool: 153 individual in 117 carpools
- Vanpool: 97 individuals in 19 vans
- Transit: 77 individuals

All vehicles are owned or leased by individual program participants.

Most program participants are clustered in a few major employment centers, including NIH in Bethesda, the Federal Triangle and L'Enfant Plaza in the District of Columbia, and the Pentagon and Crystal City in Virginia. These sites account for more than 90 percent of program participants.

Since the program met its goals, program activities have been kept to a minimum. As noted above, marketing activities have been curtailed. The program does anticipate expanding within the next few years, however, to include employer-based participation as the developer applies for additional development rights.

2.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Data on the impacts of carpooling programs comes from two primary sources. Effectiveness information on areawide programs largely comes from national studies conducted after the 1973 and 1979 oil crises. A few sound evaluations exist on individual programs as prepared by regional ridesharing agencies or state funders. The other source of evaluative data comes from assessments of successful employer programs. Case studies performed in 1982 and evaluations performed in 1989 for the U.S. Department of Transportation provide information on the impacts of employer programs. Data on developer-sponsored programs is scarce because TDM plans are often articulated and approved by a local jurisdiction, with "success" more often based simply on the implementation of the program and not its ultimate performance among tenants and employees.

2.5.1 Area-wide Programs

Most comparative studies of the impacts of areawide carpool programs report findings in terms of vehicle miles of travel (VMT) reduced, a more precise indicator than the absolute number of trips reduced and clearly better than simply reporting the number of match lists produced by registering commuters in the matching system.

In 1975, a U.S. DOT report made an estimate of the VMT reduction potential from area-wide carpool programs. The range of total VMT reduction was estimated to be between 0.5 percent to 2.0 percent and the range of work trip VMT reduction at 1.5 percent to 7.0 percent. Another forecasting exercise estimated that if all large employers promoted ridesharing in an area, work trip VMT could be reduced by 6.6 percent, non-work trip VMT would increase by 1.4 percent due to a vehicle left at home, and an overall VMT reduction of 1.7 percent for all travel would be reached.

Actual VMT reduction, obtained from 15 area-wide programs operating in 1977, was 0.05 percent to 0.28 percent for all travel and 0.14 percent to 1.0 percent for work trips. These estimates were inflated to account for commuters who are indirectly influenced to rideshare, but the results are still less, on average, than those forecasted by the earlier U.S. DOT study. In fact, the Los Angeles data from 1977 showed that the 40 million mile reduction in VMT accounted for 0.07 percent of all VMT and 0.2 percent of work trip VMT. ("*Transportation System Management: An Assessment of Impacts,*" Wagner, Fred A.; Gilbert, Keith, Alan M. Voorhees, Inc., for US

Department of Transportation, Urban Mass Transportation Administration\Federal Highway Administration, November, 1978.)
The CTS data cited above suggests that daily VMT savings in 1989 were closer to 1.0 percent of all VMT and perhaps 2 percent to 3 percent for work trip VMT.

The difference between the forecasted and the actual reductions is likely due to the inability of many programs to penetrate the commuter market by failing to work directly with a significant proportion of employers in a given area. The recent CTS data, however, may suggest that in the face of a regional trip reduction regulation, employer penetration is much higher and the matching programs somewhat more effective.

In terms of improved rideshare rates, the National Ridesharing Demonstration program compared results (1980 - 1982) for five programs in large urban areas and concluded that the results ranged from a two percent decrease in ridesharing (Portland) to a two percent increase (Houston). This study also concluded that the direct impact of area-wide programs was probably minimal, given only 2 percent to 3 percent of existing carpools cited these programs as directly influencing their mode choice. ("*Analysis of Commuter Ridesharing Behavior at Five Urban Sites,*" Booth, Rosemary; Waksman, Robert, Transportation Research Record #1018, pp. 33-40, 1985.) Using data from the same time period and many of the same urban areas, another study estimated that between 0.4 percent and 1 percent of the areas' total employment were placed into carpools annually as a result of the program. ("*Improved Air Quality in Maricopa and Pima Counties - Applicability of Transportation Measures,*" Cambridge Systems, Inc., for the U.S. Environmental Protection Agency, Region IX, November 1986.)

More recent evaluations seem to paint a somewhat brighter picture. A 1986 evaluation of 16 area-wide rideshare programs in Virginia shows that almost 5,000 commuters (out of a base of almost one million or 0.5 percent) were placed into carpools as a result of the programs in 1985 for an annual reduction in VMT of 6.5 million miles. ("*Statewide Evaluation of Ridesharing Programs in Virginia,*" Virginia Department of Transportation, 1986.) Data compiled by CTS in 1990, in Los Angeles, suggests that 15 percent of all existing ridesharers were carpooling with someone from a CTS match list ("*The State of the Commute: Research Findings,*" Commuter Transportation Services, 1991). Finally, a 1986 comparative report performed for the Environmental Protection Agency concluded that the area-wide VMT reduction potential of ridesharing programs averaged 0.3 percent (with a range of 0.1 percent to 3.6 percent) of all work trips, based on national experience. ("*Improved Air Quality in Maricopa and Pima Counties - Applicability of Transportation Measures,*" Cambridge Systems, Inc., for the U.S. Environmental Protection Agency, Region IX, November 1986.)

Is this small reduction in VMT worth the effort? The key question may be: how many ridesharing arrangements would fail or how many more vehicles would be on the road in the absence of area-wide commute management organizations? How much higher would the area's drive alone share be in the absence of an organized program to assist employers and commuters? Does the rideshare agency play a key maintenance role by placing new carpoolers into existing carpools when family, neighbors or co-workers can no longer rideshare? The answers are clearly speculative, but make an argument for considering these programs as insurance policies against additional traffic or as a program that is key to maintaining the existing proportion of commuters using alternatives.

Overall Finding: **Area-wide rideshare matching and promotion programs reduce work trip VMT by 0 percent to 3 percent. They do so by influencing a small, but significant proportion of ridesharers into choosing carpooling. The bulk of ridesharers, however, carpool with family and neighbors or as a result of employer-sponsored programs and incentives.**

2.5.2 Employer Programs

While employers rarely implement carpool matching and promotion programs by themselves, the empirical evidence shows that effective employer-based TDM programs manifest themselves in increased carpooling, and to a lesser extent, increased vanpool and transit use if specific incentives are offered for these modes. Employer-based effectiveness is most often cited as percent trips reduced or percent shift to carpooling.

A 1990 FHWA study on TDM effectiveness estimated that 11 employer programs from around the U.S. reduced trips from a low of 5 percent (at the University of California, Los Angeles) to a high of 48 percent (US West in Bellevue, WA). ("*Evaluation of Travel Demand Management Measures to Relieve Congestion,*" COMSIS Corporation; Harold Katz & Associates, for the Federal Highway Administration, Report No. FHWA-SA-90-005, February 1990.) The difference between the employer programs with high trip reduction compared to low trip reduction seems to be the existence of parking management and commute subsidy programs. Therefore, one could conclude that the programs with matching and promotion alone might be expected to reduce trips by less than 10 percent. In fact, one study of suburban employment centers concludes that on-site rideshare coordination alone can be expected to reduce trips by up to three percent as compared to centers with no programs. ("*An Assessment of Travel Demand Approaches as Suburban Activity Centers,*" K.T. Analytics, for the U.S. Department of Transportation, TSC, July 1989.) Other studies have concluded that employer programs that include carpool matching and preferential parking can reduce trips by up to 22 percent. (*"The Effects of Ridesharing Programs on Suburban Employment Center Parking Demand,"* Aarts, Jan; Hamm, Jeff, Seattle/King County Commuter Pool, 1984.) In fact, of the over 20 employer programs studied as part of this effort, the average carpooling rate is 22 percent as compared to 12 percent at control sites with no carpooling program or regional carpooling rates. Again, the reader should be reminded that the results observed among employers (an average of 20 percent reduction in trips) are largely due to the incentives and disincentives offered to employees, rather than to the matching and promotion programs alone.

Overall Finding: **Employer-based rideshare matching and promotion is probably more effective than areawide efforts alone, and employer programs have been documented with reducing trips 20 percent over prevailing conditions, but these results are largely due to the financial incentives and parking management strategies observed as part of the most effective employer program. When evaluated alone, carpool promotion might only be expected to reduce trips a few percentage points.**

2.6 COST EFFECTIVENESS

The cost effectiveness of carpool programs, both area-wide rideshare programs and employer-based programs, is again skewed by the fact that the programs being evaluated are not exclusively carpool programs. However, cost effectiveness data is available for the early area-wide programs and more recently for both area-wide and employer programs.

2.6.1 Area-wide Programs

Consistent with the measures of effectiveness cited in "Travel and Traffic Impact Potential" above, the measures of cost effectiveness are most often stated as cost per carpooler placed or cost per VMT reduced. The 1978 Carpool Demonstration Project Evaluation from the FHWA provides information for annual program costs, cost per new carpooler placed, cost per carpool daily trip, and cost per VMT reduced. The average annual cost for the 22 programs evaluated was $140,000 with a range of $30,000 to $660,000. (*"Transportation System Management: An Assessment of Impacts,"* Wagner, Fred A.; Gilbert, Keith, Alan M. Voorhees, Inc., for US Department of Transportation, Urban Mass Transportation Administration/Federal Highway Administration, November, 1978.) This range compares to a recent survey of non-profit rideshare organizations of $19,000 to $2.5 million. The cost per person placed into a carpool averaged $47 in the mid-1970's as compared to $144 among Virginia programs in 1985 and $123 per person placed by CTS in 1990. The average cost per carpool person trip was $0.10 in mid-1970's and the cost per VMT reduced was $0.024, comparable to the Virginia state-wide statistics in 1985 ($0.02). (*"Statewide*

Evaluation of Ridesharing Programs in Virginia," Virginia Department of Transportation, 1986.)

2.6.2 Employer Programs

For employer programs, cost effectiveness is measured as the cost to employers per trip reduced and the average cost per daily vehicle trips reduced. Among the 12 employer programs examined as part of the 1990 FHWA study and a few other programs, the cost per daily trip reduced was $1.31. This was calculated by dividing the total program costs by the number of trips reduced resulting from the program. The costs ranged from zero to over $11.00 per trip reduced at U.C.L.A. ("*Cost Effectiveness of Travel Demand Management Programs,*" COMSIS Corporation, prepared for Maryland-National Capital Park and Planning Commission, 1990.) The Pasadena City Hall example cited above realized a net cost of $7.02 per daily trip reduced. The annual cost of over $300,000 was off-set by $150,000 in parking fees generated. The breakdown of program expenses for the Pasadena example is as follows: commuter subsidies (49 percent), administration and marketing (12 percent), parking enforcement (6 percent), a one-time cost for program planning and implementation (3 percent), and increased employee compensation costs from union contracts (31 percent). (Nearly all the City's unions negotiated $25 or more in additional wages to compensate employees for the parking fees.) Thus, the costs associated with carpool matching and promotion are at most 15 percent (administration, marketing and start-up) of the total, or less than $50,000.

Overall Finding: **Empirical evidence suggests the following costs associated with various measures of carpool program effectiveness have been documented:**

Cost per Person Placed by Area-wide Program	**= $120-140**
Cost per VMT Reduced by Area-wide Program	**= $0.02**
Cost per Trip Reduced by Employer Program	**= $1.10**

2.7 IMPLEMENTATION ISSUES

The implementation of carpool programs largely revolves around the matching systems used by both area-wide programs and individual employers. Generally, carpool programs, no matter how implemented (employer, developer, rideshare agency), require several key elements for success:

- a pool of prospective commuters who might share rides;

- sound market research information on types of employees to target for rideshare matching and promotion;

- good, up-to-date information on commute options and potential matches made available to interested employees in a timely manner;

- a "personalized" approach to persuade employees to try carpooling and contact a fellow worker or even a stranger;

- high-level corporate support by employers so that carpooling becomes part of the "corporate culture";

- financial support to assure a sound, lasting program; and

- supporting programs which staff the carpool program, distribute marketing materials, promote specific incentives and generally promote the carpool program and other commute alternatives.

Specific to area-wide commute management organizations, the primary issue concerns their ability to have a measurable impact on travel and traffic. Perhaps the issue involves reinforcing their role of preventive maintenance in assuring that ridesharing levels do not slip region-wide while employer programs attempt to increase the number of trips removed via commute alternatives. The experience of these area-wide programs in working with employers and testing innovative strategies should be parlayed along with newer efforts, such as TMAs and trip reduction ordinances. It should also be noted that these organizations alone serve to group commuters that are not affiliated with any employer program. While a significant proportion of ridesharing arrangements are made informally between family members, neighbors or co-workers, many commute management organizations have realized an important role in maintaining carpools as they replace existing ridesharers into existing carpools.

Perhaps the greatest asset of commute management organizations is their regional commuter database. These organizations maintain large databases with which to match individuals from the same or neighboring firms. Attempts to balkanize the database by establishing unique data sets at Transportation Management Associations (TMA), individual employers and at other agencies should be avoided. Rather, small data sets for an adjacent area are quite useful if maintained in a complementary fashion with the regional data base. In fact, area-wide databases can be downloaded, updated and expanded for site-specific programs.

Carpool matching systems should have the following characteristics to be optimally successful in inducing commuters to use alternatives:

- The requestor should be given accurate, useful, timely and comprehensive information on potential matches, and information on all alternatives (including transit and alternative routes) should be included.

- Personalization and follow-up will maximize use of the "match lists." Commuters are often reluctant to contact a stranger, so the information should also be provided to the TMA or employer's in-house coordinator so that follow-up and face-to-face meetings can be arranged.

- The database should be updated and purged regularly. A rapidly mobile work force means that information that is more than six months old is likely to be unusable.

- Create a flexible database that can be segregated by type of commuter and allow the database to be downloaded into forms for use by individual companies, TMAs or for special events.

- Assure that security features are built into the system so that employers and commuters can be confident that the information is not used for other purposes and to maintain confidentiality within a single employer.

- Provide for on-line, interactive matching for those calling-in for information or for use by remote locations at employers or TMAs that experience "walk-in" requests.

- Matching systems used by employers for their own in-house programs should be menu- or screen-driven for ease of use and able to operate on most available personal computers. Quick processing time is a must as employees often request information on a "walk-in" basis.

Carpooling will continue to account for the largest proportion of non-solo commutes. The ability to assist individuals in finding someone with which to share a ride, coupled with the time and financial incentives afforded by several critical supporting strategies, will assure the proportion of carpoolers remains high.

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A.3 VANPOOL PROGRAMS

3.1 DESCRIPTION OF STRATEGY

Vanpools represent an important alternative to driving alone, falling midway between transit and carpools in terms of carrying capacity and flexibility, economics and convenience to the user. Vanpools usually involve groups of 7 to 15 people -- mainly commuters -- travelling together in a passenger van on a routine basis. Normally, one member of the group serves as the driver, and also assumes the responsibility for the organizational and maintenance details of the operation. Riders typically pay a weekly or monthly fee to cover expenses to the driver, who frequently rides free and may have off-hours use of the vehicle.

The concept of vanpooling has only been in existence *formally* since 1973, when the 3M Company in Minnesota established a program for its employees. *Informally,* however, group-ride arrangements of more than four individuals using a van or large station wagon have probably been operating for some time. Their numbers have been obscured by a lack of formal census, and to some extent made covert by issues of insurance, tax and legal liability. Estimates of vanpool use nationally, therefore, vary widely. A national survey by the National Association of Vanpool Operators in 1984 estimated that *organized* vanpooling moved about 100,000 commuters daily in over 10,000 vans ("*California Vanpool Guide,*" CALTRANS, Jan. 1990). Data from the 1990 Nationwide Personal Transportation Survey (U.S. Department of Transportation) suggests that about 0.3 percent of all work trips nationally are made in a shared ride vehicle with five or more occupants (COMSIS, November 1991).

To form a vanpool, it is necessary to:

- Identify a group of at least seven travelers whose trip patterns, time schedules, and personal characteristics are sufficiently compatible to form a stable, ride-sharing unit.
- Support the cost of acquiring, fueling and maintaining a vehicle.
- Find an acceptable arrangement for sharing responsibility in terms of driving, organization/scheduling, and vehicle maintenance.
- Assume the risk and expense of insuring the vehicle.

Because of these responsibilities and uncertainties, a number of alternative arrangements have evolved to encourage vanpools to form and remain viable. Some of these arrangements have specifically developed to bring in the support of external groups which assist the vanpool in startup and/or operation. For simplicity, the three fundamental methods of vanpool organization are described below (*Metro Vanpool Market Analysis:* Conway Associates/Wirth Consulting for Municipality of Metropolitan Seattle, 1986):

1. *Owner-Operator Vans:* This is the simplest and oldest arrangement, where the van is owned or leased directly by an individual. In this instance, the owner has complete responsibility for organizing the vanpool and assumption of all financial arrangements and risks. Vans formed under this type of arrangement have provided the basis for the more formal and institutionalized programs described below.

2. *Employer-Sponsored Vanpools:* Many employers purchase or lease vans for use by their employees. Riders are then charged a fare which represents their share of the operating and capital cost of the vehicle. In many cases, the driver is either not charged a fee or allowed personal use of the vehicle. This arrangement allows employers a mechanism to subsidize or support the vanpool in direct or indirect ways. Examples of employer-sponsored vanpools include 3M, the Tennessee Valley Authority (TVA), and CONOCO in Houston.

3. *Third-Party Vanpools:* In this arrangement, a third party organization such as non-profit corporation, private vendor or transit agency acquires the vans and makes them available to employers or individual users. The vans are leased to the users at rates which are based on the costs of the vehicle, maintenance, fuel and insurance. The third-party administration costs may or may not be rolled into the fares. Rather than directly leasing vans, some public agencies restrict their third party role to forming vanpools only, referring their riders to private leasing companies for the equipment. Examples of this arrangement include Commuter Transportation Services, Inc. in Los Angeles, a non-profit regional agency (200 vans in 1984), and the Tidewater Regional Transportation District, a regional transit agency (95 vans in 1984). Vanpool Program Services, Inc. (VPSI), is perhaps the most distinct third-party service vendor; a subsidiary of Chrysler Corporation, VPSI provides full-service van acquisition, operating and administrative assistance to employers and individuals nationwide.

3.2 NATURE OF EFFECTIVENESS

The effectiveness of vanpooling is viewed differently by the three primary groups concerned with such programs: society (as represented through government agencies), employers and individual travelers.

SOCIETY:

To society, whose concerns are primarily the resource needs for transportation capital programs, and environmental issues such as air pollution, energy consumption and highway intrusion, vanpooling offers relief as a vehicle trip reduction measure. Because vanpools carry between 7 and 15 passengers per vehicle trip, each vanpool potentially removes a similar number of single-occupant vehicle trips from congested highways. Moreover, because vanpools normally serve longer trips, they can have an even greater impact on reducing vehicle miles of travel (VMT), which is a primary determining factor in highway capacity needs and vehicular emissions. More recently, vanpool programs have been established or encouraged to provide access to suburban job opportunities for inner city workers.

The number of passengers carried by a vanpool allows it to serve an important niche in the transportation market. Where it is difficult to have traditional transit service function viably in an increasingly dispersed, low-density environment, a van:

- requires fewer passengers than a transit vehicle to be viable; and
- from a cost perspective, the vanpool is self-supporting.

To the extent that there are concerns about vanpooling, they probably center on the issue of vanpool competition with transit service, and hence possibly reducing transit's cost-recovery potential in certain markets.

EMPLOYERS:

For employers or developers who are under requirements to reduce trips in conjunction with trip reduction, growth management or air quality initiatives, vanpooling is a potentially effective option for meeting these requirements. Vanpools also represent a potentially cost-effective way for employers to gain access to labor pools which are either mobility or economically restricted (particularly those which reside in inner cities or distant rural areas). Some employers have claimed that vanpooling has indirectly helped their business by raising employee morale and reducing absenteeism and tardiness.

If employers have objections to vanpools, they would appear to be concerning:

- the cost and administrative burden of setting up and operating a formal vanpool program;
- adherence to a vanpool travel schedule compromising professional staff commitments and performance; and

- employees or proprietary information being lost to other firms if a pool mixes employees from different employers.

INDIVIDUAL TRAVELER:

For the traveler, the primary concern is more oriented toward having a cheaper, less aggravating method of travel. In this regard, having a viable vanpool alternative offers the benefits of possibly reduced cost, convenience, more effective use of travel time, and freedom from driving and the use and wear on one's own vehicle. Many vanpoolers like social aspects of vanpooling, with the pool groups developing tight, long-term social bonds. The retention rate for vanpools is high, with over 90 percent of persons starting in a vanpool staying with it. (*California Vanpool Guide,* CALTRANS, January 1990.)

Vanpooling, like any other strategy that is to be effective, must first address the needs, concerns and characteristics of the traveler. Travelers will not be drawn in large numbers into vanpools because they are "good for society", or because promotional efforts change their attitudes. Vanpools must be perceived as offering tangible benefits. Assuming that the natural tendency of a commuter would be to drive alone, (assuming a car is available), the following considerations are important when evaluating the option of riding in a vanpool:

- *Increased Travel Time:* Driving alone means traveling directly door to door from home to worksite, with the only inconvenience being minor parking and walking times at either end of the trip, and delay due to congestion enroute. To vanpool, the traveler often experiences longer travel times. This results from either having to travel to a pick up location, or traveling on a circuitous route to pickup or drop off other riders. What this generally means is that vanpools, to be perceived as being advantageous to the individual traveler, serve longer trip lengths where these additional time penalties become a smaller portion of the overall trip.

- *Schedule Constraints:* By definition, driving alone offers the commuter optimal flexibility. In contrast, a vanpool imposes schedule rigidity. Given the number of persons who rely upon the vanpool for reliable service, a vanpool's schedule must be relatively strict. This both takes away an element of freedom from the individual, as well as imposes a constraint on work hours. Professionals who frequently find it necessary to work late or have unpredictable hours may find the rigid schedule of a vanpool too confining or unrealistic.

- *Cost Factors:* Sharing costs in a multi-passenger, shared-ride arrangement would presumably result in attractive costs to the vanpool traveler in compared to driving alone. However, SOV travelers frequently fail to perceive a compelling cost advantage, for two primary reasons:

(1) SOV users often do not regard the full costs of operation when making their travel decisions. They tend to regard the obvious and routine out-of-pocket (parking or tolls) or operating (fuel) costs, and disregard the costs of vehicle ownership and depreciation, maintenance, insurance, and taxes and fees.

(2) Parking at employment sites is frequently free or heavily subsidized. Were SOV users to realize the actual cost of parking on site, this would enter into the cost comparison and greatly offset the apparent cost advantage of driving.

In light of these factors, and based on the principle that a vanpool is financially self-sustaining, travelers *might not* in many cases conclude that the shared cost of a vanpool is sufficiently less to make it more attractive than driving alone, particularly for shorter trips.

To make vanpools more attractive, it is necessary to fashion policies or procedures which take away or make up for some of those disadvantages. A number of these are described as *supporting strategies* in the next section.

3.3 APPLICATION SETTING

The conditions outlined in this section define the best application opportunities for vanpooling. In addition, measures which can be applied to enhance the applicability and market for vanpooling are discussed.

TRAVEL MARKETS:

For reasons mentioned earlier, the market for vanpooling has been limited primarily to long-distance commuters. The reasons for this lie in the minimum travel distance/time necessary to make the cost per mile and total trip time after group assembly attractive relative to alternatives. Estimates vary, but it is generally thought that a one-way trip length of at least 20 miles is the minimum necessary to support a vanpool (*California Vanpool Guide,* CALTRANS, January 1990). Because only about 9 percent of U.S. workers have trips that exceed 20 miles, this prequalification would appear to place a sharp upper limit on the initial market potential for vanpooling.

The market for vanpooling has also been associated with large employers, i.e., those employing 500 or more workers at a single site (*Metro Vanpool Market Analysis:* Conway Associates/Wirth Consulting for Municipality of Metropolitan Seattle, 1986).

Traditionally, only large employers have been able to supply the necessary large numbers of potential trip matches that would enable a vanpool to form. Nationally, employers of this size account for only about 25 percent of all employment situations. Assuming that workers at large employment sites have the same trip characteristics as the national work force, the implied upper limit for vanpooling would be 9 percent x 25 percent, or 2.2 percent of all trips.

However, after considering the role of subsidized employer parking, vanpool cost self-sufficiency, and comparative travel time impediments, it becomes evident that the market limitations on trip length are somewhat artificially imposed, and can be affected by strategic actions which will be described later in this section. Similarly, aside from those situations where employers are in isolated locations, the limitation of vanpooling to only the largest employers is also subject to challenge. This limitation is more rooted in historical issues of employer insurance liability and fears of information or employee loss, than ride-matching possibilities.

TRAFFIC CONDITIONS:

Traffic congestion works to improve the attractiveness of virtually all alternatives to driving alone, including vanpooling, by making the act of driving itself longer and more onerous. However, while congestion makes driving alone less attractive, it doesn't make riding in a vanpool any shorter, since in most cases the vanpool must drive on the same crowded roads as single occupant vehicles. There are measures which can be applied to free the vanpool from some of these congestion problems, through one or more types of priority/preferential treatment. These measures are described later in this section.

SETTING:

Vanpools can function viably in most any setting. Interestingly, they may be at their greatest advantage in some of the settings traditionally served by transit, specifically from suburbs into congested Central Business Districts. Here they benefit both from efficiencies in grouping sufficient numbers of riders, as well as economic discouragements to driving, such as scarce and expensive parking. Where vanpools have an advantage over transit, however, is that they can reach into the farther, lower-density suburbs (or "exurbs"), because they require fewer passengers to be viable, and those passengers find the most efficient way to assemble and meet with the service.

Of course, not all successful vanpool programs have required a higher-density destination in order to be viable. Many of the most renowned vanpool examples in the country support destinations in outlying areas where employees are traveling long distances and where there is little or no public transit service. The 3M Company, which is described as an example in Section 3.4, is one such case. The 3M site is located at the exurban fringe of the Minneapolis/St. Paul metropolitan area, and draws employees to its 12,700 employee base from throughout the metropolitan area. The vanpool is effectively a "paratransit" type of service for those employees who prefer not to drive. The Tennessee Valley Authority (TVA) program and the program at Louisiana Land and Exploration are also examples of the same phenomenon.

Vanpools also have important geographic application for the "reverse commute" market, i.e., transporting workers from inner-city residential sites out to new suburban employment sites. While transit agencies are attempting to realign their services to meet this growing need, these are difficult markets for transit to serve, logistically and financially. Vanpools, on the other hand, seem better equipped to match the origin-destination and concentration characteristics of these travelers.

TYPE OF TRAVELER:

Apart from time and cost factors, studies also suggest that vanpoolers tend to be drawn from certain socio-economic groups. In particular, data indicate that a high percentage of existing vanpoolers hold white-collar jobs and earn above-average incomes. Table 3-1 was compiled by Seattle Metro in its 1985 Vanpool Ridership Survey ("*Metro Vanpool Market Analysis,*" Conway Associates/Wirth Consulting for Municipality of Metropolitan Seattle, 1986).

These data indicate that between 67 percent and 73 percent of all vanpool riders in these three geographic areas had jobs in professional, technical, management, or administrative occupations. The data also suggest that vanpoolers are primarily male, with an average age in the early 40's.

The tendency of vanpools to draw from professional rather than blue-collar ranks is of some interest. It would seem that factory workers, for example, would be more likely to be faced with a relatively consistent work schedule than professionals, whose day is more frequently marked by unpredictable meetings and late night deadline efforts. This may be the result of industrial employees seeing vanpooling as an option of inferior status to driving, or the failure of employers to promote vanpooling out of fear of losing employees or information, or stimulating union activity in non-union shops. As a challenge to these national statistics, the Boeing Company in the Seattle/King County region sponsors a vanpool program that in 1984 accounted for about 1,400 of its 80,000 workers. It would appear that many of these vanpool riders are manufacturing employees.

TABLE 3-1

Characteristics of Vanpool Riders

	San Francisco Golden Gate	Maryland Vango, Inc.	Seattle METRO
Occupation (percent of total)			
Professional and technical	55%	58%	53%
Management and administration	16%	15%	14%
Clerical and sales	18%	19%	19%
Crafts, operators, and laborers	8%	2%	10%
Service	1%	0%	3%
Other	2%	6%	2%
Average age (years)	40	41	42
Sex (percent males)	63%	57%	55%
Income ($ 1985)	$37,000	$45,000	$37,000

Source: Seattle METRO 1985 Vanpool Ridership Survey.

Supporting Strategies:

There are a number of measures that can be taken by governments or employers that can remove or lessen some of the identified barriers to vanpooling, and in the process increase the attractiveness of vanpools to the traveler.

Travel Time

Travel time penalties incurred in picking up or dropping off passengers can be made up through priority measures that give time savings back to vanpoolers. (These measures are covered in detail in Section II A.4.) The most common of these are:

- *Priority HOV Facilities:* Making available special lanes for vanpools (and other high occupancy vehicles) that allow them to bypass congestion and travel at a higher rate of speed. Providing bypass ramps on freeway entrances and special exits for HOV only is also an effective way of providing time savings.

- *Preferential HOV Parking:* By providing close-in parking for vanpools (and other HOVs) at worksites, and forcing SOVs to park further away, walk time savings are afforded to vanpoolers. Because travelers place a value on the time spent outside a travel vehicle that is 2.5 times as large as the time spent in the vehicle, this can be an important incentive, provided the time savings difference is significant. If the vanpool priority spaces are also reserved or sheltered, it makes the incentive effect that much greater.

Scheduling

In order to use a vanpool, one must either be able to adapt his/her schedule to the pool, or find alternative means to travel on those occasions where he/she cannot connect because of a conflict. These concerns are handled in two major ways:

- *Flexible/Variable Work Hours:* Vanpoolers may be more inclined to use a vanpool if the employer permits some flexibility in the setting of hours to be compatible with the needs of the pool. For some employers, this means scheduling meetings or activities for time periods that don't threaten the pool, or at least accepting employee departures in order to meet the schedule of their pool. (These concepts are discussed in detail in Section II C.1.)

- *Guaranteed Ride Home:* Studies have shown that an important reason for driving a car to work is a perceived need to have a car available in case of a family emergency, or for working late. One solution to this problem is to offer an alternative method of travel, in case of such situations occurring, ranging from a free or discounted taxi ride to use of a company fleet vehicle. (These concepts are discussed more in Section II B.1.)

Travel Cost

Vanpools are generally expected to be financially self-supporting, meaning that all costs related to the ownership and operation of the vehicle must be covered by the riders. Whereas employers might be inclined to subsidize employee vanpools until recently, Federal tax law placed strict guidelines on such practices. Under current law, employers are permitted to subsidize both transit and vanpool use up to $60 per month without tax liability accruing to the employer (carpools are not eligible for subsidy under current law). Prior to the enabling 1992 Energy Bill, vanpoolers could not be subsidized, and, in fact, to the extent that drivers were permitted non-work use of an employer-provided van, they were obligated to report that privilege as income to the IRS.

These restrictions notwithstanding, there are important ways in which employers can reduce the cost and financial risk of vanpooling to employees:

- *Lifecycle Capital Depreciation:* The typical van is financed over a three to five year loan cycle, and the average cost calculated over this time period is what is used to determine the average fare. In reality, the service life of a van is much longer than three to five years. To lessen the cost impact on its employees, the Aerospace Corporation, in El Segundo, California purchases the vehicles outright, and then leases them back to employees at a rate reflecting a 10 year "life-cycle", which greatly reduces the cost to users. This is an important and implicit subsidy that makes vanpooling very popular at Aerospace. Aerospace maintains the vehicles in its on-site facility, so that they perform effectively over the 10 year life cycle. This example is presented in greater detail in Section II A.3.4.

- *Parking Charges/Subsidies:* Obviously, one of the biggest discouragements to SOV use is the absence of free and unrestricted employer parking. Placing a charge on SOV parking is one of the most important ways to make vanpooling (as well as every other alternative mode) more attractive. The existence of priced parking also makes it possible to grant an implicit subsidy to vanpools by providing them with discounted or free parking. US West in Bellevue, Washington imposed a $60 monthly charge for SOV parking on site, but allows vanpools and carpools of three or more to park free in reserved spaces (*Evaluation of TDM Measures to Relieve Congestion*, Federal Highway Administration, February 1990).

- *Insurance:* Insurance is both a legal and a cost issue to vanpools. Liability laws vary from state to state, and insurance industry assessment of risk varies from company to company. Insurance is a necessary expense item for vanpools. Employers can greatly assist this process by intervening to secure the necessary coverage through their own auspices. 3M, as one example, is self insured, and simply extends this coverage to its vanpools.

- *Startup Cost and Risk Minimization:* A major impediment to the formation of a vanpool is reaching the necessary number of passengers. How long will it take to reach this number of passengers? How many riders are necessary to have a viable pool? What do you do with the vehicle if the vanpool disbands or never reaches viability? These are important deterrents to considering a vanpool. Firms such as Aerospace have provided empty seat subsidies to ease the cost burden on the van during its time of growth or when its ridership is fluctuating.

Government agencies have been instrumental in addressing some of these cost-related barriers:

- Under its East Side Action Plan and the Easy Ride Program, Seattle Metro offered "one month free" and "early start" subsidies to employees who would try vanpools, enabling them to get started before acquiring the full complement of riders (*Seattle Metro Suburban Mobility Case Study,* UMTA, October 1990).

- The State of Connecticut provides low interest loans and the opportunity to buy a new van or minivan at wholesale prices to individual owner-operators, and then permits the unit to return the van within the next year if it cannot become viable (*ACT NOW Newsletter, Vol. XIV, No. 3,* May/June 1990).

- Montgomery County, Maryland, as part of its Fare Share program, offered a one-time subsidy to vanpools with at least 8 new passengers amounting to over $2,100 over 18 months (declining monthly subsidy payments).

3.4 EXAMPLES

3.4.1 State of Connecticut Vanpool Incentives Program

The State of Connecticut has devised a comprehensive program of assistance and incentives to encourage commuter interest in vanpooling. The features of this program are strategically designed to address the key obstacles to vanpool formation and stability.

The program permits would-be owner-operator units to purchase a van at very attractive terms. By working through one of the three state non-profit ridesharing organizations -- Metropool in southwestern Connecticut, The Rideshare Company in the Hartford area, and Rideworks in the New Haven/Waterbury area -- financing can be acquired for the purchase of new full size or minivans. Potential pools can secure 2.5 percent/60-month financing for up to 90 percent of the cost of full-size vans, and 5 percent/60-month financing for up to 80 percent of minivans. To make this arrangement even more attractive, the program:

- Has identified dealers who are willing to sell vehicles at virtually wholesale price;

- Allows the vanpool units to start up with as few as three persons per minivan and seven persons per full-size;

- Offers a 22 percent rebate on gasoline sales tax for vans used in-state; and

- Allows the pool to disband within the first 12 months if it cannot become viable; on only 30 days notice, the van can be returned for refund of down payment, or can be transferred to another owner.

To further facilitate formation, the three regional ridesharing organizations provide assistance in finding the riders to form a pool through a statewide Commuter Register (a listing that reaches over 90,000 commuters per month), and working with the individual pool to find insurance, establish a fare structure, and to help monitor van maintenance needs.

The program started in August of 1991, and through November 1991 had sold 40 vans, or about one every 13 days, according to The Rideshare Company in Hartford, Connecticut. Sales were stable through the fall 1991 recession. There have been no buyers who have disbanded the vanpool they created and returned the van. A preliminary evaluation indicates that almost all of the new van owners were former drive alones, as well as almost all of their passengers. The exception is some former carpool members. Hartford Rideshare's perspective on the carpool to vanpool shift is that it increases vehicle occupancy and thus is good. The carpoolers are, in effect, "growing up" to a higher occupancy, according to Byron York, Marketing Director.

The approach of the program is to offer commuters a tangible benefit, for example, a mini-van. Half of the sales to date have been mini-vans. A mini-van is a vehicle with a much bigger household appeal than a 15-person van. The Connecticut program gives dealers showroom brochures that are comparable in quality to the manufacturers' literature. For example, a Dodge mini-van with 12.9 percent/60-month factory financing would cost $383 a month with 20 percent down and a $1,000 factory rebate, according to Mitchell Dodge of Simsbury, Connecticut, a participant in the program. The 5 percent interest subsidy from the State would bring the cost down to $318 a month. Five riders at $50 each a month would bring the monthly cost down to $68 (Byron York, Marketing Director, The Ridershare Company, Hartford, Telephone Interview 11/15/91).

The brochures typify the drive behind the program's effort to reach for new markets. The mini van market will typically be for shorter commutes of 10 miles, as opposed to 20 miles for full-size vans, which means a larger market. Passenger savings from vanpooling are lower on the shorter commutes, but so is the time penalty paid in vanpool pickups because the number of passengers is smaller. The market will also be larger because more people want mini-vans than full-size vans. Since Hartford Rideshare also offers both full size vans and the carpool register, it has products to reach a variety of commuter needs (*The Rideshare Company,* November 1991).

3.4.2 BECHTEL Vanpool Program

Bechtel is a consulting and engineering firm that needed to expand its space at its Gaithersburg, Maryland site, but did not have room to expand without using land taken up by parking. The need to reduce parking was thus the impetus for the program. Even though the company eventually expanded to a second site (also in Gaithersburg), the program continues and serves both sites.

The Bechtel vanpool program has a long history. It has evolved over time into a program in which the company purchases vans and maintains them. Volunteer drivers are selected by the company, but the driver cannot use the van at home for personal travel.

Passengers pay a weekly fare through payroll deduction. Fares range from $9 to $13.25 a week. A unique feature is that there are also casual riders, who pay 1/5 of the weekly rate plus a $0.50 handling charge for each day they use the vans. The vans have an exact departure point each morning and leave on time even if all passengers are not there. In the evening, vans wait till all of the morning's inbound riders are present. Guaranteed ride home is provided by either company cars or an on-site Avis office.

Employees who want to vanpool sign up with the vanpool office. If they reside near a pool with an available slot, they are assigned to it. A waiting list is kept, and routes with low utilization are combined or eliminated.

From a peak of 42 vans, Bechtel now operates 29. In 1990 the program cost $219,000, and all but $30,000 was recovered through fares and daytime use of the vehicles by Bechtel departments.

The program illustrates several points. First, it demonstrates the tradeoffs between land purchase and reduced parking. Bechtel determined that they could get land for expansion cheaper by using existing parking and then implementing vanpooling rather than through the purchase of new land, although the numbers are not now available. Second, corporate attitude has played a large part in the program's success. It is considered an honor to be selected to drive a van. Third, not surprisingly, the program is most attractive to employees who live a long distance from the Gaithersburg offices. The average distance is about 33 miles. Fourth, the cost per trip reduced by the program is low, and has dropped with experience. From a starting cost of $400 per trip reduced, the program is now down to $160 per trip reduced.

3.4.3 Aerospace Corporation and the Space and Missile Program (SAMSO) of the US Air Force

The two employers at this location have more than 6,000 employees. About 18 percent of the employees vanpool to work. The program has its roots in a subscription bus service started in 1973 and a carpool matching service in 1974. When the subscription bus service was terminated in 1974, at the peak of the gas shortage, carpooling reached a peak of 38 percent of the workforce (Case Book USDOT '83).

In 1975, a vanpool program was started by Aerospace Corporation. The program, as it now stands, serves 15 percent of the workforce at the two organizations. Carpooling remains common, with 19 percent of the workforce using carpools. Average vehicle occupancy for all employees is 1.5 (Torluemke and Roseman, 1990).

Participation in the vanpool program costs $85 per month for a 100-mile roundtrip commute. Fares vary with the length of the commute. Vanpools, as well carpools, get reserved parking next to building entrances, but the time savings are not substantial, according to Irv Jones, the full-time program coordinator. There is no charge for SOV vehicles to park.

Company support for the program is strong. It should also be noted that the administrator of the program is a strong advocate for it, and a leader in the local Chapter of the Association for Commuter Transport (ACT). One indication of effectiveness is that 13 of the program's 60 vans serve commutes between 10-20 miles long. Since vanpool pick-ups often take time, it is sometimes argued that they are only effective for longer trips that compensate for the time lost in pool formation.

There are at least two reasons why the Aerospace program is effective. First, there is strong management support. Second, low fares are available due to amortization of the vans over 12 years. Maintenance is performed by the company including rebuilding of engines and refurbishing of interiors after 120,000 miles. The program is billed for this work. Aerospace charges $76 for an 80-mile round trip, in a full cost recovery program. A similar trip in a van provided by a third-party vendor at a nearby McDonnell - Douglas' plant is $100.

3.4.4 VPSI (formerly Van Pool Services, Incorporated)

VPSI, a subsidiary of Chrysler Corporation, buys Chrysler vans for its 5000 vehicle fleet and uses Chrysler Credit to finance them and Chrysler dealers for service. It has 40 employees, 25 customer service centers, and projected annual revenues of $40 million for 1991. The Los Angeles area provides 25 percent of its revenue. No other major car company operates a similar program.

Typically, VPSI has no formal contracts but provides a vanpool at the request of employees. It normally takes 12 to 15 employees to form a vanpool, and the pools form and dissolve quickly. Customers can dissolve a vanpool with 30 days notice. VPSI also provides services under contract to state and local governments and large employers (*Automotive News,* July 1, 1991, p. 22).

According to the representative of VPSI's Washington office, the drivers have unlimited use of the van after working hours, and pay no fare. Passengers' fares are $70 to $95 per month plus a share of the gas and of the parking charges at the work site. VPSI picks up maintenance and repairs on the vehicles, which they replace after four years. The typical life of a vanpool is also about four years. VPSI helps attract new riders to weak vanpools, and develops new vanpools primarily through marketing the program to the human resource directors of companies.

VPSI feels that HOV lanes are a major incentive to vanpool, estimating that VPSI vanpools on the Shirley Highway HOV lanes in the Washington, D.C. area outnumber VPSI vanpools on other radial freeways by a ratio of 3:1.

The program appears to be quite profitable. Assuming a fare of $80 per month, for 12 riders for 12 months, gross revenue per van to VPSI is $11,520 per year. For rough estimating purposes, assume the van is fully financed at payments of $400 per month over four years. The purchase and financing costs incurred per van will be $4,800 per year. If that figure is doubled to cover repairs, servicing and company overhead and marketing, the profit per van is $11,520 - $9,600 = $1,920, or nearly $2,000 per van per year.

3.4.5 3M Company

The 3M Company is generally credited with originating modern-day vanpooling. The 3M Center, located in the low-density suburban fringe, east of St. Paul, Minnesota, is the international headquarters of this major corporation. The Center employs about 12,700 administrative and research personnel on an exclusive 420-acre campus that consists of 24 buildings and about 10,000 square feet.

In 1973, one of the Company's traffic engineers was presented with a corporate expansion program that called for the construction of hundreds of new parking spaces. Realizing the impact that the expansion would have on an already serious traffic situation, he proposed to management that the money be allocated instead to purchase vans that could be used as "large carpools" by employees. Aided by the early-70's fuel crisis, the inaugural program became a rapid success and helped spawn hundreds of other similar corporate programs.

Vanpooling wasn't the only transportation management strategy employed by 3M to deal with its progressively worsening traffic problems at the Center. Trends were clear in 1970 (when employment was at 7,700) that employee vehicle use would eventually limit the growth potential at the Center, with 91.6 percent of employees driving alone. A significant measure of early relief was gained through the institution of a staggered work hours policy, which split the arrivals of research and administrative staff into two distinct groups, separated by 30 minutes. The company also experimented with subscription bus service in the early 1980's, contracting with the Metropolitan Transit Commission for dedicated service, but dropped the program due to usage and cost factors. A Ride-Guide carpool program is also supported, which is essentially a self-help locator guide for interested employees.

Despite the effectiveness of its carpool and staggered hours programs, 3M is most closely attached to its vanpool program. In designing its program, 3M wished neither to make a profit from the program or to have it regarded by employees as a subsidy. The original concept was to purchase and lease back a 12-passenger van to a qualifying employee unit of at least nine employees plus a driver. The driver was not required to pay a fare, was allowed personal use of the van, and was given all passenger fares beyond the nine-passenger cost-covering minimum. To determine cost structure, 3M depreciates the vehicles over a five-year period, with an assumed resale value at the end of the period. The operating costs are then added based on the daily round-trip miles.

While 3M does not directly subsidize the vanpool program, several cost advantages accrue to users. First, because 3M is self-insured, the cost of insurance for the vans is modest. Second, the vans are maintained in 3M's shops. A fleet of backup vehicles is available to cover the downtime of the regular vans. Third, the company's administrative costs are not passed on to the vanpool. And finally, in some instances, individual departments have purchased the vans and turned them over to the pool as a contribution.

As of 1985, the program operated 105 vans, approximately half of which are 12-passenger and half seven-passenger. As shown in Table 3-2 on the following page, 7.8 percent of the company's 12,700 employees travel by van, or about 990 people. This represents as many as 885 (990 - 105) single occupant vehicles that do not travel to the site each day. While this is not as high a number as was set back during the energy shortage in 1979/80 when vanpool use reached 135 vans and 10.8 percent of the employment base, it still represents a significant trip reduction measure for 3M that also earns them the respect and loyalty of their employees. The 3M van groups have developed into long-term social groups, with strong ties to each other, the van unit and 3M.

TABLE 3-2

Effectiveness of 3M Company Program Over Time

Year	1970	1974	1977	1980	1985
Employment	7723	9476	10,711	11,740	12,700
Method of Travel					
Drive Alone	91.6%	81.3%	82.0%	79.9%	82.7%
Carpool	13.0%	20.1%	14.0%	14.8%	14.1%
Vanpool	0%	6.0%	8.7%	10.3%	7.8%
Transit	0.6%	1.2%	1.7%	1.8%	1.7%
Vehicle Trips per 100 Employees	91.6	81.3	82.0	79.9	82.7
Average Vehicle Occupancy	1.09	1.23	1.22	1.25	1.21

Reference: *Effectiveness of Travel Demand Management Actions in Alleviating Traffic Congestion.* COMSIS Corporation for the Federal Highway Administration, February 1990.

3.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Vanpooling will reduce vehicle trips and traffic levels to the extent that it draws travelers from lower-occupancy modes of travel -- in particular, the Single Occupant Vehicle (SOV). If a vanpool carries an average of 12 travelers per vehicle trip, then it could eliminate as many as 11 individual vehicle trips, if each of the vanpool passengers previously drove alone.

Of course, the assumption that all potential vanpoolers are SOV users is not valid, since in virtually all instances, some portion of a travel population will travel by other means. And to the extent that higher occupancy modes are already being utilized, the net trip reduction from vanpooling will be less. A simple way to represent this background level of non-SOV travel is through the Average Vehicle Occupancy (AVO) rate, or AVO (private vehicle users divided by private vehicle trips). The higher the AVO is above 1.0, the greater the existing use of higher occupancy vehicle modes and the less impact vanpooling will have on vehicle trip reduction.

Table 3-3 illustrates the potential reduction in vehicle trips if a vanpool program were implemented and enjoyed different levels of usage under different starting conditions, as reflected by AVO. Four different background environments are represented by the AVO measures in the table:

TABLE 3-3 Commute Vehicle Trip Reduction				
	Vanpool Market Share of Commuter Trips			
AVO	0.3%	1.0%	5%	10%
1.05	0.3%	0.9%	4.6%	9.2%
1.10	0.3%	0.9%	4.5%	9.1%
1.15	0.3%	0.9%	4.5%	9.0%
1.30	0.3%	0.9%	4.4%	8.9%

- AVO of 1.05 represents a highly SOV-dependent environment, typical of many new, low-density suburban growth areas.

- AVO of 1.10 represents a slightly better situation, with a little less SOV dependency and some use of carpooling; there is probably little or no transit use; this rate is the national average for commuter trips (*1990 NPTS Early Results,* FHWA, August 1991).

- AVO of 1.15 represents the type of vehicle utilization commonly found in suburban corridors or in suburban activity centers; the non-SOV travel is primarily multi-passenger vehicle, and may involve very slight amounts of transit use.

- AVO of 1.3 is what might be found in a radial corridor into a CBD, and probably involves some usage of transit.

Assuming that a vanpool would transport an average of 12 passengers, the table estimates the percent vehicle trip reduction that would occur if the vanpool market share (percent of persons using vanpool) were 0.3 percent, 1.0 percent, 5 percent and 10 percent. Please note that the trip reductions in the table are somewhat less than the vanpool share, because not all persons who switch to vanpool were formerly SOV users. Note particularly that as the AVO increases, the net reduction for vanpooling is less because it is penetrating a progressively higher-occupancy environment. On the whole, however, each percentage point increase in vanpool utilization yields almost a direct return in vehicle trips taken off the road.

Table 3-4 demonstrates a similar assessment with regard to another measure of effectiveness, vehicle miles of travel, or VMT. Given that vanpool trips are generally longer than trips by SOV or carpool, an SOV or carpool trip shifted to vanpool would conceivably yield even higher returns in VMT reduced. Using the same conditions as in Table 3-3, Table 3-4 indicates the percent reduction in VMT that would occur assuming the trip reductions from 3-3 are multiplied by a trip length factor that represents the longer nature of vanpool trips. Assuming that the average vanpool trip is at least 20 miles, compared to an average length of a commute trip from the 1990 NPTS of 10.9 miles, each vanpool trip could conceivably reduce almost twice as much VMT as vehicle trips (83.5 percent is the factor used in Table 3-4). This has important implications for not only congestion, but air quality emissions as well.

TABLE 3-4

Commute VMT Reduction

	Vanpool Market Share of Commuter Trips			
AVO	0.3%	1.0%	5%	10%
1.05	0.6	1.7	8.5	16.9
1.10	0.6	1.7	8.4	16.7
1.15	0.6	1.7	8.3	16.5
1.30	0.6	1.6	8.2	16.3

Assessing the impact of vanpool usage on actual traffic conditions requires extension of the analysis to a transportation network, where it is necessary to account for the mixture of travel contributed by other market segments that do not use vanpool.

Traffic congestion in a transportation network is generally represented by a "level of service" indicator. Traffic engineers grade the service quality of a transportation facility or network in degrees, ranging from A, which is free flow, to F, which is failing. A numeric measure to approximate this level of service is the Volume to Capacity Ratio, or V/C. As this ratio approaches the value of 1.0, traffic volumes are matching the design capacity of the facility and level of service begins to break down. In fact, at levels above 1.0, the facility's carrying capacity begins to diminish.

Table 3-5 extends the analysis of Table 3-3 to assess the effects on areawide congestion might be of successively higher levels of vanpool utilization. It assumes a transportation network condition where the Average Vehicle Occupancy is 1.15, and the V/C ratio is 1.0, which means that the traffic volume in the system is operating at the design capacity of the roadway system. The table illustrates the effect that successively more ambitious vanpool programs would have on the area-wide V/C ratio, depending on the proportion of the traffic being affected by vanpool programs, i.e., commute trips. Situations are depicted where commute trips are 100 percent, 75 percent and 50 percent of the trips operating in the system (typically during peak period).

TABLE 3-5

Net Impact on Traffic Congestion

Commute Trips Percent of Total Travel	Vanpool Share		
	1%	5%	10%
100%	0.99	0.95	0.91
75%	0.99	0.97	0.93
50%	0.99	0.98	0.95

The table suggests that the V/C ratio of 1.0 could be reduced to 0.91 (virtually another level of service) if vanpool share were at 10 percent and the travel base were exclusively commute trips. Even at a 75 percent share of commute trips, which is a more typical balance of travel during a peak period in an activity center or corridor, a 10 percent vanpool share could reduce the V/C to 0.93, which would be a significant improvement in level of service.

If a 10 percent vanpool share of commute trips could produce a level of service difference in a congested highway network, the question is: could a 10 percent commute share by vanpooling be realized? It appears from the empirical data on existing programs that individual employers who have incorporated vanpool programs have been able to achieve vanpool mode shares on the order of 8 percent or greater. These employers are all large, however, with most of the successful examples being employers with 4,000 or more employees, and the employees who use vanpools tend to make longer trips.

Table 3-6 estimates the potential market for vanpooling using two conventional measures: size of employer and distance. The table axes list the distribution of the U.S. worker population by size of employer and by distance of a one-way trip. The table then indicates the cumulative percentage of workers who fall within that combined employer size/distance category.

TABLE 3-6

Market Potential

		Trip Distance (in miles)					
		30+	21+	16+	11+	6+	All
Employer Size	Cum. Distribution	3.4%	8.4%	14.9%	25%	46.3%	100%
500+	25%	0.8%	2.1%	37%	6.3%	11.6%	25%
100+	50%	1.7%	4.2%	7.5%	12.5%	23.2%	50%
50+	61.6%	2.1%	5.2%	9.2%	15.4%	28.5%	61.6%
All	100%	3.4%	8.4%	14.9%	25%	46.3%	100%

The table suggests that if the market for vanpooling was workers in places of employment of 500 or more who traveled at least 20 miles one-way to work, then the upper limit would be only 2.1 percent of the population. If we relax the assumptions on minimum trip length and/or employer size to allow for shorter trip lengths or smaller companies, the potential market begins to grow, but is still modest within conventionally-established boundary parameters. Assume that the market for vanpooling would include:

- Trips of 11 or more miles for the largest employers of 500+ (25% x 25%)
- Trips of 16 or more miles for large (100 to 400) employers (14.9% x 25%)
- Trips of 21 or more miles for medium (50 to 99) employers (8.4% x 11.6%)

Then approximately 10.9 percent of all employees would be included in this eligibility definition. Of course, virtually all of these employees would have to be drawn into vanpools in order to attain the overall 10 percent market share for commute trips, which is logistically unlikely, so perhaps 5 percent is a more realistic goal.

It is worth noting, however, that the limits on vanpooling are primarily a function of the marketplace. Right now, most vanpoolers choose to ride a vanpool simply to escape from the chore and expense of a particularly long daily commute. The economics and time analysis only begin to look favorable when the trip length approaches 20 miles. Similarly, trip matching logistics favor large single employment concentrations for reasons of modest long-distance trip potentials. Should conditions in the marketplace change regarding the economic incentive to vanpool, as would occur through either substantial vanpool subsidies or SOV parking disincentives, the break-even distance for commuters to find vanpools cost-effective could be brought down substantially. Aerospace Corporation, discussed earlier as a case study, is a good example of how the economics can be used to affect the market for vanpooling.

3.6 COST EFFECTIVENESS

The effectiveness of vanpooling as a travel option in cost terms relative to other courses of action is again best described in terms of its impact on three groups: society at large, employers, and the individual traveler.

Cost to Society

To society, which can mean "government" or, more properly, those who provide the resources to fund public programs, the primary cost associated with mobility is that of providing and maintaining the necessary physical transportation capacity to allow an individual to travel without undue restriction. If the individual wishes to accomplish the trip through use of a single-occupant vehicle (SOV), and that vehicle trip places an additional demand upon a facility which is already operating at capacity in the peak period, then that trip can only be accommodated through the addition of new capacity. In an analysis using extensive highway construction and maintenance data from its *1990 Maryland State Commuter Assistance Study*, COMSIS Corporation estimated the *cost to society* to supply the necessary incremental highway capacity to support an additional SOV trip demand at $6.75 per one-way trip (1992 dollars). This assumes a work trip of 10.5 miles in length, and incorporates both capital and O&M costs. (See Part III, Section 3.4 for a more detailed summary of this analysis.)

If the traveler made the same 10.5-mile work trip in a 12-passenger vanpool, assuming the vehicle itself did not require any additional highway space due to its size than a standard automobile, the cost to society per person transported would be reduced to $6.75/12 or $ .56, representing a savings per one-way trip of $6.19. This level of savings totals $12.38 per day and $3,220 per year for every person trip that would be made in a vanpool rather than in an SOV.

With the possible exception of transit service in high-density corridors, the vanpool may be the most cost-effective travel option available to society. Applying the same analysis to carpooling, assuming the occupancy of the average carpool would be 2.5 travelers, the societal cost would be $2.70 per one-way trip, reflecting a savings over SOV of $4.05. Transit, while it carries more passengers than a vanpool, also (1) requires about 60 percent more highway capacity than a van, and (2) requires a public subsidy to meet its outstanding costs after farebox revenue. The cost per person trip in transit is estimated at $4.10, which is still a $2.65 savings over SOV, but $3.54 more than the same trip by vanpool.

The cost savings through vanpooling increase with the length of the trip. The 10.5 mile reference trip reflects national trends in SOV trip length for home-based work trips (1990 NPTS Survey), while the average vanpool trip is generally much longer. Of course, the only way in which these highway capacity savings are credible is where the trip in question is challenging the capacity of the existing highway system. If the highway segment is not at capacity and can accommodate additional travel, the savings are not as relevant in present terms, but may reflect future opportunity costs if the buildup in traffic pushes the requirement for new capacity.

COST TO THE EMPLOYER

Employers become involved in finding commute alternatives for employees for several reasons; chief among these are:

- To cap or reduce the expense for employee parking;
- To acquire space for facility expansion;
- To satisfy legal or regulatory requirements to reduce vehicle trip generation or traffic congestion; and
- To provide an employee benefit, or to affect employee productivity.

Against these tangible and intangible benefits, employers compare the costs of alternative programs. A research paper published by Professor Frederick Wegmann is quite informative in drawing upon the results of a national survey of almost 900 employers, 160 of which were private, to assess the costs and benefits inherent in employer-based ridesharing programs. Of the 160 respondents, 141 were judged to have active ridesharing programs.

The major cost typically borne by employers to support employee travel is in the provision or subsidization of parking. Of the 160 employers, 78 percent provided free parking to their employees, while 10 percent of the remaining employers charged a nominal fee that was less than the actual cost of the parking to them. The sample was split as follows:

- 27.3 percent in central business districts;
- 25.9 percent in central cities, but not the CBD;
- 36.7 percent in suburban areas; and
- 10.1 percent in rural areas or small towns.

Over 33 percent of these employers indicated that they experienced parking shortages. While these were most commonly large employers and those located in CBDs, 32 percent of those in non-CBDs and 18 percent of those in rural areas also reported shortages. For those 72 firms who were able to report data on their costs to provide parking, the average total financial commitment came to $64 per space and $73.50 per employee per year. However, for those 38 firms who estimated the cost to provide *expanded parking*, the cost averaged $3,930 per space, suggesting a very high penalty cost to providing overflow parking.

Employer expense in operating a vanpool program falls into two primary categories of cost: administrative and direct operating costs. To the extent that the vanpool program does not cover these costs (operating or operating and administrative, depending on the firm's policy), then the employer is granting a *subsidy*, either openly or implicitly.

In the sample of 160 employers, 67 indicated that they were providing vanpool services, either by leasing the vehicles or by outright ownership. Of particular interest among these were the 58 firms who operated their own vanpool programs; this group accounted for a total of 1,236 vans, or an average of 23 vans per firm. Among these:

- 36 percent indicated that they set riders' fares at a level sufficient to cover all operating costs, but not administrative;

- an additional 5 percent used tax credits inherent in owning the vehicles to help cover operating costs;

- 21 percent set fares high enough to provide a net positive return to the firm; and

- 50 percent were operating at a financial break-even point or better before including administrative costs.

When administrative costs were included, the number of break-even programs was reduced to 10 (17 percent), and four (7 percent) still realized a net positive return.

When administrative costs were not considered, the average subsidy per van paid by the sample of employers was $1,283 per year per van. If administrative costs are considered, they add $70/year per van. *Significantly, even with administrative charges, 60 percent of the firms paid $0 to $10,000 per year to support their vanpooling program.* Assuming 12 passengers per van, this subsidy works out to $12.35/year per employee, compared to $73.50 per year per employee to provide parking. Thus, based strictly on a justification related to the avoidance of parking, vanpooling offers the employer almost a 6-to-1 advantage. Consideration of less tangible benefits further enhances the attractiveness of this option. (Wegmann, *Cost-Effectiveness of Private Employer Ridesharing Programs: An Employer's Assessment.* Transportation Research Record 1212.)

COST TO THE INDIVIDUAL

To the individual traveler, choice of a particular travel mode confers the following primary benefits:

- Savings in cost over the next most expensive alternative;
- Savings in travel time over the next most attractive alternative, and in particular, savings in the components of travel time that are attributable to walking or waiting out of vehicle; and
- Various levels of *reliability, comfort, and convenience* associated with the person's particular sociodemographic situation, perceptions and personal preferences.

For many contemporary travelers, whose commutes take place entirely or partially in suburban/low density areas, most of these benefit determinations will be maximized by choosing to travel in a private vehicle, and probably by driving alone. Generally, use of alternative modes will take more time (particularly the more onerous out-of-vehicle time), and will involve sacrifices in reliability, comfort and convenience. Only in situations where congestion is particularly acute or commutes particularly long, will ridesharing or transit usage offer some comfort, convenience and reliability benefit.

From a pure cost point of view, however, the alternative modes will not compare attractively with the SOV, even though ostensibly they are more economical. This has much more to do with how those costs are conveyed to or perceived by the traveler than their actual relationships. As most of us know by now:

- Parking benefits provided by employers frequently carry significant cost to the employers, but are not passed on to employees; as indicated in the previous section, parking costs employers an average of $73.50/year per employee.

- Travelers themselves tend to consider only the short-run marginal costs associated with using private vehicles; in other words, they consider only the fuel costs and whatever obvious out-of-pocket costs they experience on a daily basis (tolls, parking fees), and ignore the much larger costs of vehicle ownership, including capital cost, maintenance and insurance.

Depending on how these costs are figured into the individual's analysis, vanpooling is or is not an attractive option. Table 3-7 performs a simple cost analysis to show the impact of these cost comparisons. Shown in the table are comparative costs for driving alone versus vanpooling for different trip lengths under different cost assumptions.

The first set of numbers characterizes SOV costs. Using data compiled by the Motor Vehicle Manufacturers Association for 1988 on the cost of operating an automobile, the average cost per mile to operate an automobile assuming an annual utilization of 10,000 miles is $0.458, of which only 9.1 cents are operating costs (fuel, oil), while 36.7 cents account for the fixed costs of depreciation, maintenance and insurance. Out-of-pocket costs like parking and tolls are not included. Therefore, if the average commuter considers only the marginal costs of fuel and oil to represent the cost of using an automobile for the work trip, the cost per mile will be a straight 9.1 cents per mile for any trip length.

If only short-run SOV variable costs are considered, clearly, riding in a vanpool will only begin to show cost savings to justify the additional time for group assembly at significant trip distances, typically 20 miles or more. Table 3-7 illustrates the passenger cost per mile and per trip over different trip distances for the Aerospace situation, as an example of a good employer-operated van program. What these data reflect are (1) a declining cost per mile with trips of longer distance, and (2) a breakeven point in cost per mile comparison with the SOV that occurs somewhere between the 30 and 40 mile trip lengths. This helps explain why Aerospace's vanpool program has such a high percentage of employees using vans for trips of under 20 miles.

It is commonly accepted that employer-operated vans generally offer the lowest cost to users, while third-party or vendor-supplied vans represent the highest cost option, with owner-operator vans falling somewhere in between. While directly comparable data by mileage group for owner-operator or third-party arrangements were not available, the Torleumke/Roseman paper obtained information from operations at neighboring McDonnell Douglas. The user cost for third-party vans is available for round trip distances of 80 miles and 140 miles; user cost per mile is 6.3 cents and 4.2 cents, respectively for these two markets. It can be seen that (1) these costs are cheaper than SOV variable cost for the same distance, but (2) more expensive by 25 percent or more compared to the employer-assisted efforts at Aerospace. The

TABLE 3-7

Comparative Cost of SOV vs Vanpool (per person cost)

Round Trip Distance (miles)	Single Occupant Vehicle					Vanpool			
	Cost per Mile[1]			Cost per Trip		Employer (Aerospace)[2]		3rd Party[3]	
	Variable	Fixed	All	Variable	All	Per Mile	Per Trip	Per Mile	Per Trip
30	7.3¢	18.5¢	25.8¢	$2.19	$7.74	7.5¢	$2.25		
40	7.3	15.5	22.8	2.92	9.12	6.2	2.48		
50	7.3	13.3	20.6	3.65	10.30	5.4	2.70		
60	7.3	11.7	19.0	4.38	11.40	4.9	2.94		
70	7.3	10.4	17.7	5.11	12.39	4.5	3.15		
80	7.3	9.4	16.7	5.84	13.36	4.3	3.44	6.3¢	$5.00
90	7.3	8.6	15.9	6.57	14.31	4.0	3.60		
100	7.3	7.9	15.2	7.30	15.20	3.9	3.90		
110	7.3	7.3	14.6	8.03	16.06	3.7	4.07		
120	7.3	6.7	14.0	8.76	16.80	3.6	4.32		
130	7.3	6.3	13.6	9.49	17.68	3.5	4.55		
140	7.3	5.9	13.2	10.22	18.48	3.4	4.76	4.2	5.86
150	7.3	5.6	12.9	10.95	19.35	3.3	4.95		

References:

1 Motor Vehicle Manufacturer's Association, *Motor Vehicle Facts and Figures '88*, Detroit, MI, 1988, p.44.

2 Torleumke and Roseman, *Vanpools: Pricing and Market Penetration*, Transportation Research Record 1212.

3 Vanpool Services, Inc.

average trip length of the McDonnell Douglas vanpools is more than twice as long as the Aerospace experience, indicating the sensitivity of travelers to comparative costs.

For either vanpool arrangement, the point where vanpools become attractive comes at much shorter trip lengths if full costs of auto ownership and use are considered. The table shows the impact of including the fixed cost in this comparison. Assuming that the average commute trip length is 8.5 miles, and that is the daily mileage inherent in the 10,000 mile annual automobile use rate on which these statistics are based, a simple calculation was made to approximate fixed costs for higher annual mileages such as would be caused by longer commute trip lengths. Thus, if the fixed cost per mile for the basic 8.5 mile trip is 24.8 cents, a 15 mile trip (30 mile round trip) would increase the annual mileage base to the extent that the average fixed cost per trip would decline to 18.5 cents, and so forth, declining steadily with commute trip length. Were consumers to consider these total costs, the SOV trip would no longer appear a bargain, and even for round trips under 30 miles, the vanpool could represent significant savings, particularly for the Aerospace cost structure.

Unfortunately, travelers are never likely to look at these real but less visible costs of SOV use. The types of costs that would enter into consideration, however, would be out-of-pocket charges that they would have to consider on a daily or routine basis, such as tolls, SOV parking fees, or alternatively, direct vanpool subsidies. From these data, it can be seen that even modest cost incentives/disincentives could push the breakeven mileage for vanpooling much lower than it currently is, even by Aerospace standards.

3.7 IMPLEMENTATION ISSUES

Despite the significant appeal of vanpooling as a medium-density modal option with high traffic-impact potential and traditional economic self-sufficiency, efforts to boost use of the mode will meet with numerous barriers. At a minimum these include the following:

- Public transit operators are likely to fear competition from vanpooling in certain markets.

- Some public transit operators will actually see cost and other advantages to higher levels of vanpool service in their service areas, but may be constrained by political, institutional and funding issues in seeking to make greater use of vanpool options.

- While some employers view vanpools as an important employee benefit and management strategy, many employers are resistant to vanpooling for such reasons as:

- Loss of flexibility when employees must leave at a certain time to join their vanpool;

- Added administrative bother and expense, with the result that vanpooling is placed in the hands of third parties or owner-operators at higher cost to the traveler;

- Concerns about their employees mixing with the employees of another employer, for reasons of information loss, employee loss, and even concerns about insurance coverage.

- Federal tax laws restrict issuance of private subsidies to vanpools as non-taxable income, which discourages most employers from financially assisting pools.

- Many transportation planners, employers and individual travelers perceive vanpools as being limited to only special situations, namely long commute trips and large employers.

Many of these barriers can be mitigated and the utilization of vanpools greatly increased:

- With regard to possible competition with public transit, it may prove cost-effective to rely on vanpool to serve various transit markets that are not easily served by transit; however, this will require local policy changes that are most likely to be motivated by financial factors.

- Employers may become more favorable toward vanpools as they attempt to meet trip reduction requirements under the new Clean Air Act Amendments, which may result in a greater tendency to assist in their formation, operation, and economic viability.

- Vanpool market penetration need not be limited to trips of 20 miles or more if favorable economics and commensurate time savings are made available. This can be achieved through subsidy schemes, SOV parking disincentives and development of such time saving measures as preferential HOV lanes, access and parking. Again, these elements may become more common under the pressures of the Clean Air Act.

- Finally, the perceptions of individual travelers toward vanpooling as a mode for long trips only may be altered if either the economics or travel time considerations are made more favorable through the measures described above.

3.8 REFERENCES

For more information on Vanpooling, the following references are of particular value:

Torluemke, D.A. and Roseman, D. *Vanpools: Pricing and Market Penetration,* Transportation Research Record 1212. This paper provides an excellent overview of the vanpool program at Aerospace, and through a comparative analysis with a neighboring program, insight as to the role played by economic incentives.

Frederick J. Wegmann *Cost-Effectiveness of Private Employer Ridesharing Programs: An Employer's Assessment,* Transportation Research Record 1212. This paper draws on an extensive national survey of employers to examine costs and benefits associated with operation of employer vanpool programs. Key benefits include diminished parking costs to employers, and the analysis reveals that on this measure alone, vanpools are cost justified.

For particular guidance on more practical matters of program design, implementation and management, the following sources are recommended:

- *Do It Yourself Vanpool Guide,* Publication of Washington State Ridesharing Organization and Department of Transportation.

- *California Vanpool Guide,* California Department of Transportation, January 1990.

- *Vanpool Implementation Handbook,* U.S. Department of Energy, Office of Transportation Programs.

A.4 BICYCLE/PEDESTRIAN FACILITIES AND SITE IMPROVEMENTS

4.1 DESCRIPTION OF STRATEGY

Bicycling and walking are often overlooked as serious travel options in the United States. In older U.S. cities, and in Europe and other parts of the world, these modes constitute a very important part of the transportation system. In the modern, suburban environment that characterizes most U.S. metropolitan areas, however, these modes seem out of scale and out of place. Distances between residences and activities are discouraging to pedestrians and bikers in this environment; further, these distance barriers are magnified by environmental design factors that either prevent direct paths, or that put pedestrians or bikers in conflict with vehicular traffic. Hence, biking and walking seem inappropriate to the environment, and hence are typically not given great weight in transportation planning or policy schemes.

The essence of Travel Demand Management is one of managing the overall transportation system to its highest efficiency by drawing upon all travel options to the extent that they can contribute, and creating a balanced environment where there are numerous options available. In this regard, there may be more potential to bicycling and walking than might appear at first glance, both in a direct and in a complementary relationship. To clarify, there are three important ways in which bike and walk modes might be pushed into greater service in transportation management programs:

- **As Primary Modes:** realistically more people could use biking or walking as a primary mode instead of driving, if given appropriate opportunity and encouragement.

- **As Feeder Mode:** bike and walk can be an effective media to connect with transit (or ridesharing) modes for longer trips, again if given appropriate opportunity and encouragement.

- **For Circulation:** the degree to which a destination site or activity center allows convenient circulation impacts travelers' decisions on how to reach the site in the first place, i.e., whether they are dependent on a private vehicle to ensure mobility once at the site.

Even with the great limitations presented by the built environment, it is reasonable to conclude that rates of biking and walking, particularly for non-recreational purposes, are considerably less than their potential. If greater advantage could be taken of the situations where biking or walking are legitimate alternatives, even at marginal rates beyond current levels, impacts on traffic levels and air quality could be consequential. The sections which follow attempt to shed light on the factors which aid or impede biking and walking, and identify strategies which might be effective in alleviating these barriers.

4.2 NATURE OF EFFECTIVENESS

The benefit of increased usage of bicycle and walking modes is obvious, in that they replace a motorized person trip with a non-motorized trip. From the standpoint of traffic congestion and highway capacity, higher rates of bicycle/pedestrian usage should reduce vehicle trip demand and traffic congestion, provided that the non-motorized travel and the vehicular travel do not unduly conflict. From the standpoint of air quality, diversion of travelers from motorized modes to bike/walk is of obvious benefit, although because the trips are relatively short, the primary benefit is in the elimination of vehicle trips (in terms of the "cold start" emissions) over the vehicle miles of travel, or VMT, which is saved. Shifting from motorized to non-motorized modes may also affect system traffic congestion, such that with fewer vehicles and improved speeds, emissions are reduced.

How effective could a concerted bike/pedestrian program be in affecting traffic congestion and air quality? An example to ponder is Atlanta's "Platinum Triangle", a burgeoning suburban megacenter located northwest of downtown Atlanta at the intersection of the circumferential freeway and Interstate 75. In a 2-mile by 4-mile space, this area supports an employment base of roughly 60,000 and a residential population of about 59,000. Of course, most of the residents do not work within the Platinum Triangle, although data indicate that approximately 10,000 do hold jobs within the subarea, and 7,300 of these were found to reside within 1 mile of their work location. This proximity of home and workplace notwithstanding, virtually all of these commuters drove alone to work; average vehicle occupancy in this area was measured at 1.04 persons per vehicle, and there was no transit service in existence. During the congested peak hour, approximately 27,000 vehicle trips were operating on the subarea's road network; if even a portion of the 7,300 residents who had a bike or walk option had been engaged to do so, traffic congestion could have all but disappeared in this area. However, based on the design of this rather typical suburban center, there were no sidewalks or bike facilities connecting either the residential and employment areas, or the commercial/employment activities themselves. ("*Cobb County Suburban Mobility Study*", COMSIS for the Cobb County, Georgia Department of Transportation, 1990).

What type of person is likely to consider biking or walking? Generally, they fall into three classes:

- **Income:** persons and households with severe income limitations may have to walk or bicycle out of necessity.

- **Preference:** persons who have walking/biking as a convenient option and simply choose to use it, which may also include persons who choose not to own an automobile or believe that walking/biking are environmentally or socially responsible choices.

- **Exercise:** persons who will devote additional effort to biking or walking because it represents structured physical activity and exercise for them.

Indeed, biking or walking represents these three primary benefits to users: It represents a cost savings over driving or using transit (unfortunately, for many, having to walk or bike for economic reasons is a sign of lower socioeconomic status, so that when additional income is realized, demand for vehicle ownership and use typically follows); it provides an opportunity for exercise; and it may even offer convenience if auto or transit use is unattractive because of traffic congestion, waiting, availability of parking, etc. The challenge in fostering greater interest in biking and walking is to try to remove or reduce some of the obvious impediments to travel by these modes, and then to find ways to encourage travelers to take advantage of the benefits listed above (economic, convenience, and exercise) given the existence of these modes as reasonable options.

4.3 APPLICATION SETTING

4.3.1 Factors Which Affect Bicycling and Pedestrian Travel

There are a number of factors that explain current patterns in the use of non-motorized modes, and which also determine ultimately how effective these modes can be as part of a comprehensive transportation management system. Understanding these factors and their role in travel choice is the first step in appreciating their importance and in framing measures that can be taken to alleviate barriers to biking and walking and stimulate greater usage and reliance.

An important source document for this discussion is a recent (1993) case study completed by Stewart A. Goldsmith for the Federal Highway Administration under its National Bicycling and Walking Study. The document, ***Case Study No. 1: Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes***, is an extremely thorough effort in trying to separate and evaluate factors behind bicycle/walking usage, and it is recommended to all practitioners who desire greater insight into these relationships. Results from this case study heavily underpin the discussion and conclusions in this section.

Evaluating the potential for bicycle/pedestrian modes starts with identifying the travel situations in which they are most suitable. Generally speaking, the most common current application for non-motorized travel modes in the U.S. is for exercise and social/recreational purposes. More "serious" travel purposes, like commuting, shopping or personal business, are more typically made by motor vehicle, *particularly in suburban environments*. These patterns are evident in the data shown in Table 4-1 taken from the 1990 Nationwide Personal Transportation Study.

Table 4-1 shows the rates at which people use bicycles or walk for trips of three different purposes: Travel to and from work, i.e., "Commuting"; Shopping and Personal Business, which includes also medical and civic/religious travel activities; and Social and Recreational travel. These specific travel purposes comprise between 85 and 90 percent of all travel in urbanized areas, with the remainder being miscellaneous "Other" (which is not shown in this table, hence percentages by purpose do not sum to 100%). For trips of each purpose, the table indicates the distribution of trips by primary travel mode, including private vehicle, public transit, walking, bicycle, and other. These patterns are reflected for three different levels of urbanized area: those with populations under 1 million; and those with population of 1 million or more, subdivided into places which have rail transit systems or not. The data further reflect behavior patterns of travelers whose residence location within these urbanized groups is inside the central city vs. in the suburbs.

The following relationships are evident in these data:

- The percentage of people who walk ranges from the 1 to 3 percent range for commute trips in smaller urban areas and areas of 1 million or more without rail transit, to the 5 to 13 percent range in areas of 1 million or more with rail transit. These percentages are considerably higher for Shopping/Personal Business trips 2 to 5 percent and 6 to 22 percent, respectively), and higher still for Social/Recreational travel (7 to 12 percent and 9 to 22 percent, respectively).

- The percentage of people who presently bike is much less than walking -- in most cases only about 10 percent as great as the walk share. For Commuting trips, bike trips range from 0.3 percent to 0.6 percent, with no obvious increase in the largest urban areas (> 1 million with rail) such as was true with walking. These rates are about the same for Shopping and Personal Business trips, and highest for Social/Recreational travel, as expected, but still only in the range of 1 percent to 2 percent of all Social/Recreational trips, again with no major difference in the largest urban areas.

Table 4-1: RATES OF BICYCLE AND WALKING USE FOR MAJOR TRIP PURPOSES

Percent of Daily Person Trips by Purpose and Mode

Trip Purpose/Mode	Urban Areas < 1 million		Urban Areas >1 Million (*No Rail Transit*)		Residence Areas>1 Million (*With Rail Transit*)	
	Residential in Central City	Residence in Suburb	Residence in Central City	Residence in Suburb	Residence in Central City	Residence in Suburb
Commuting	19.5%	20.5%	21.1%	20.5%	22.2%	22.4%
Private Vehicle	93.6%	98.6%	92.2%	96.8%	66.0%	88.7%
Transit	2.0	1.0	3.8	1.1	19.0%	6.0
Walking	3.3	1.6	3.3	1.7	13.2	4.5
Bicycle	0.6	0.01	0.6	0.3	0.4	0.2
Other	0.5	0.6	0.1	0.1	1.4	0.6
Shopping	41.6%	39.7%	42.6%	41.3%	39.1%	41.3%
Private Vehicle	93.4%	97.2%	92.7%	94.8%	71.6%	92.9%
Transit	1.0	0.5	1.1	0.7	4.2	0.7
Walking	5.1	1.7	5.6	3.6	22.5	6.0
Bicycle	0.3	0.4	0.4	0.4	0.8	0.2
Other	0.2	0.2	0.2	0.5	0.9	0.2
Social/Recreation	25.8%	25.1%	23.5%	25.2%	24.5%	24.8%
Private Vehicle	86.9	90.5%	84.8%	88.6%	67.9%	87.6%
Transit	0.6	0.2	1.1	0.6	6.8	1.0
Walking	10.6	7.1	12.0	8.3	21.6	9.4
Bicycle	1.6	1.1	1.7	1.7	2.0	1.6
Other	0.3	1.1	0.4	0.8	1.7	0.4

Source:* *1990 Nationwide Personal Transportation Study (NPTS).

- Clearly, rates of walking and biking are greater among residents of central cities vs. those residing in suburban locations. The disparity seems to be much greater with walking than with biking, however, with rates of walking being much greater in cities than in suburbs, while biking doesn't seem to be as greatly affected (perhaps because of the importance of sidewalks to walking).

Tables 4-2 and 4-3 were also developed from the 1990 NPTS Survey and show these tendencies in a slightly different format. Table 4-2 looks only at trips that are made by walking and indicates their distribution across the four basic trip purposes: Commuting, Shopping/Personal Business, Social/Recreational, and Other. It confirms that the great majority of walking trips are made for non-work purposes, with less than 10 percent of all walk trips being made for commuting in the smaller urban areas, and about 13 to 14 percent in the areas over 1 million with rail transit. The table also indicates the average length of a walking trip for each purpose, ranging from about 0.4 to 1 mile. Table 4-3 shows the same information for bicycle trips, with a slightly higher percentage of overall trips made for commuting (7 percent to 16 percent) than walking, but considerably less for shopping and personal business. The average length of a bike trip varies from 0.5 mile to as high as 3.8 miles.

While traffic congestion and air quality objectives are served by the shifting of low-occupancy vehicular trips of any purpose to non-motorized modes, obviously much more TDM impact will be realized if commute and other types of utilitarian trips are made by bike or walking since these trips more commonly make up peak period traffic demand. While the data in Tables 4-1 through 4-3 reinforce popular intuition that biking and walking are primarily used in the U.S. for pleasure and non-utilitarian travel, current use rates for work and utilitarian travel need not be considered a firm upper limit. In Europe, where development patterns are more concentrated and facilities for walking and biking are well-integrated, biking and walking are dominant methods of travel for virtually all trip purposes. And even in older American cities, walking and biking are still practical and popular ways to commute, shop, or perform other types of personal business. What are the factors that determine how willing travelers would be to consider biking or walking to accomplish commute/utilitarian trips more frequently? The factors are, as with all travel alternatives, of two types:

- *Objective*, or those things that relate to the travel environment and determine the relative appeal of biking/walking to other alternatives; and

- *Subjective*, or factors related to the individual that help shape and qualify their tastes and preferences.

Both types of factors are described below. As might be expected, these factors are somewhat interrelated, in that personal tastes and preferences are tied to experience

Table 4-2: WALKING RATES IN URBAN AREAS OF DIFFERENT SIZE

Percent of Walk Trips by Trip Purpose
(Average Trip Length in Parentheses)

	Urban Areas < 1 million		Urban Areas > 1 Million *(No Rail Transit)*		Residence Areas > 1 Million *(With Rail Transit)*	
Trip Purpose/Mode	**Residential in Central City**	**Residence in Suburb**	**Residence in Central City**	**Residence in Suburb**	**Residence in Central City**	**Residence in Suburb**
Commuting	9.0% (0.7 mil)	8.8% (0.8 mi.)	8.7% (0.9 mi.)	6.6% (1.1 mi.)	13.8% (1.0 mi.)	13.4% (1.1 mi.)
Shopping/ Personal	29.6% (0.5 mi.)	17.6% (0.8 mi.)	29.8% (0.6 mi.)	28.4% (0.5 mi.)	41.5% (0.6 mi.)	32.8% (0.6 mi.)
Social/Recreation	38.5% (0.7 mi.)	47.9% (0.8 mi.)	35.4% (0.8 mi.)	40.2% (0.6 mi.)	25.0% (0.6 mi.)	30.9% (0.6 mi.)
Other	22.9% (0.7 mi.)	25.7% (0.8 mi.)	26.1% (0.7 mi.)	24.8% (0.4 mi.)	19.7% (0.6 mi.)	22.9% (0.6 mi.)

Source: *1990 Nationwide Personal Transportation Study (NPTS).*

Table 4-3: BICYCLE UTILIZATION RATES IN URBAN AREAS OF DIFFERENT SIZE

Percent of Bicycle Trips by Purpose
(Average Trip Length in Parentheses)

	Urban Areas < 1 million		Urban Areas > 1 Million *(No Rail Transit)*		Residence Areas > 1 Million *(With Rail Transit)*	
Trip Purpose/Mode	**Residential in Central City**	**Residence in Suburb**	**Residence in Central City**	**Residence in Suburb**	**Residence in Central City**	**Residence in Suburb**
Commuting	13.8% (2.6 mil)	0.2% (2.0 mi.)	15.5% (1.8 mi.)	9.2% (2.1 mi.)	9.4% (1.2 mi.)	6.5% (2.1 mi.)
Shopping/Personal	13.6% (2.2 mi.)	24.6% (2.4 mi.)	18.0% (1.7 mi.)	23.5% (0.5 mi.)	31.2% (0.6 mi.)	11.6% (1.1 mi.)
Social/Recreation	49.2% (1.4 mi.)	43.9% (3.8 mi.)	48.2% (1.2 mi.)	56.9% (2.2 mi.)	50.3% (2.5 mi.)	64.7% (2.7 mi.)
Other	23.4% (1.3 mi.)	31.3% (0.5 mi.)	18.3% (1.1 mi.)	10.4% (0.9 mi.)	9.1% (0.5 mi.)	17.2% (0.9 mi.)

Source: *1990 Nationwide Personal Transportation Study (NPTS).*

drawn from objective performance. Also as might be expected, it is more realistic to think of altering the conditions that influence the "objective" factors through policy or program actions, and hope that these changes will influence the relevant "subjective" factors. Following a listing and discussion of the factors, specific strategies are identified which could overcome the identified barriers and enhance the appeal and use of biking and walking.

4.3.1.1 Objective Factors

Trip Distance and Travel Time

Perhaps no single factor is as important as distance in the decision to bike or walk, particularly for commute or utilitarian travel. Simple logic suggests that, because of limitations in the speed with which one can walk or bike (2 to 3 mph for walking, 10 to 12 mph for biking), distance quickly imposes an "envelope" or access barrier within which trips can be made. The Goldsmith case study lists several references which suggest that while the average bicycle trip is only about 2 miles in length (Orhn/1976 estimated 2 miles, and a 1990 Boulder, CO survey measured 2.1 miles). Bike commute trips may be longer, averaging about 5 to 6 miles (Forester/1984 estimated 4.7 miles, Deakin/1985 estimated 5 to 6 miles). This implies a willingness to travel about 30 minutes one-way for a work trip. For walk trips, Goldsmith reported data on a study from Ontario which indicated an average walk commute trip by Ontarians of 1.25 miles (20 minutes), and corroboration in a study by Robinson which found that 80 percent of walk trips were under 1 mile and 94 percent were under 2 miles. Indeed, if a 30-minute rule were applied to a 2 to 3 mph walk speed, it would translate to a 1 to 1.5 mile acceptable walking distance. The 1990 NPTS indicates an average trip length for all purposes by bicycle to be 1.8 miles, and 2.1 miles for commuting. The average walk trip in NPTS for all purposes is 0.7 miles, and 0.9 miles for commuting.

Distance is obviously a complex measure of potential for biking or walking. First, distance is a function of "where you can get to" in a given trip; if the pattern of travelable routes is indirect or does not connect with key destinations, then the "effective distance" (as the crow flies) that can be reached will be much less than the suggested maximums. In many places, it is simply impossible to access a particular destination because of obstacles or lack of reasonable facilities. Also, as Goldsmith points out, tolerable distance is an individual variable, depending on physical condition, exercise goals, site conditions, etc. And, most individuals are likely to suggest a willingness to travel farther than they are generally observed to do in practice. Transit studies, for example, routinely find that individuals are generally willing to walk more than 1/4 mile to reach a transit stop.

Goldsmith performs an analysis which tests the hypothesis that cities which have a higher percentage of commuters who have commutes of five miles or less are likely to have higher rates of bicycle use for commuting (data not available to check walking). Using a sample of data on bike commute rates from 12 cities, he found that rates were somewhat higher in the more compact cities, but other factors were also important, such as the general social and physical environment for biking.

Traffic Conflicts

As Goldsmith reports, citing the *Attitude Study for the Portland Metropolitan Bicycling Encouragement Program* (Columbia Research Center, 1982), surveys report that traffic safety as a major factor which deters individuals from bicycle commuting, although this is held as much a matter of perception as reality. People who do not commute by bicycle are highly likely to see safety in traffic as a key concern, while existing cyclists may be concerned, but have found a way to select a safe passage to enable their particular trip -- hence it is hard to separate cause and effect.

In many areas, particularly in suburban areas but also in center cities, vehicular traffic dominates the travel environment from the perspective of the pedestrian/cyclist. Even with provision of sidewalks or bike lanes, persons walking or biking along side a busy roadway will feel overwhelmed and out of scale with the speed and power of the nearby motor vehicles. This may be emphasized by limited crossing opportunities, with few or poorly marked crossing zones, missing pedestrian signals, long light cycles to maximize peak direction vehicle traffic flow, or simply a requirement to cross 6 or more lanes of highway. In many instances, even designated crossings may still be dominated by vehicle users, with poor enforcement by police of red light and right turn violations.

Travel Cost

The research literature suggests that cost factors are not a significant consideration in the traveler's decision to bike or walk. According to Goldsmith, surveys show that cost is rarely the chief factor in the decision, either because (1) the valuation of travel time dramatically outweighs potential cost savings to most people, and those who are walking or biking are doing so for other than economic reasons, or (2) people are realistically responding to the nature of the current (suburban) environment, where the cost of private vehicle use is heavily subsidized by employers and privately rationalized by individuals when they do their accounting. However, what these findings do not reflect is that, if these cost relationships were significantly altered, e.g. through either tangible subsidies to bikers/walkers or imposition of parking or other fees on private vehicle users, the benefits of biking or walking would become much more compelling than they are under current conditions. In Davis, California, for example, where 25 percent of the population commutes by bicycle (highest rate among known examples), very high parking fees at the U.C. Davis campus cause 53 percent of students to reach school by bicycle (Wilbur Smith Associates, *City of Davis TSM Plan*, April 1991). A Harris Poll survey for Bicycling Magazine indicated that, when asked what conditions would make them ride a bicycle to work, 44.5 percent of active bicycle riders and 18 percent of all adults suggested that the presence of financial incentives would make an important difference; this ranked only slightly less in importance to the top factor, having safe bike lanes (*Bicycling Magazine,* April 1991, #44).

Transportation Alternatives

The decision to bike or walk depends in an interactive way upon the availability and quality of *other* transportation alternatives. These alternatives, especially public transit, can serve in either a complementary or competitive manner. If transit service is good and reasonably priced, it may be a significant alternative to walking or biking, and in that sense serve as a competitive substitute. However, transit service which can be readily accessed on the residential or destination end also expands the range and viability of walking or biking, allowing them to serve as *feeder* modes. And vice-versa, the ability to walk or bike to or from a transit service greatly supports the utilization of that transit service.

Environmental Factors

The shape and nature of both the natural and man-made environment can pose important obstacles to bikers and pedestrians. The following are often given consideration:

Physical Environment

- Topography: Terrain has a shaping effect on market shed with biking and walking. In areas where terrain is more rugged, where users must negotiate hills, valleys, streams and other natural obstacles, acceptable bike/walk distances would seem to be less than where straight-line paths would permit greater efficiency. Ironically, however, urban areas like San Francisco and Boulder, Colorado have considerable topographic features, and yet have unusually high rates of pedestrian and bicycle use; much seems to depend on the local setting, population, and how well the obstacles have been reduced by built facilities.

- Climate and Weather: According to Goldsmith, weather is regularly mentioned in surveys as a factor in the decision to bike or walk. However, it appears that weather is best viewed as a seasonal or day-to-day factor than a sweeping factor related to climate in general. In areas with either very cold winters or very hot summers, desire of travelers to bicycle or walk may wane in extreme conditions, although rates of biking and walking are strong in both Madison, Wisconsin and Phoenix, Arizona when weather permits. When this occurs, the pedestrian or cyclist may either shift to public transportation or revert back to private vehicle use. Generally, pedestrians can cope with climatological or meteorological fluctuations reasonably well, but bicyclists may not be as flexible. Because they involve more energy output, bicycles may not be as attractive on hot days, particularly if the individual travels a long distance, or if there are inadequate changing facilities at the destination. Similarly, bikes may not seem as flexible in rainy or snowy weather, when safety and exposure are both an issue.

Man-Made Environment

- <u>Segregated, Low-Density Land Use Patterns:</u> Traditional neighborhoods allowed for residents to accomplish virtually all of their necessary personal and economic functions within a short distance from home. Households could conveniently reach schools, stores, athletic facilities, churches/civic activities, and even jobs on foot or by bicycle. Longer trips to the urban core for such purposes as employment, major retail, entertainment, etc., could frequently be made by transit. In post-World War II development trends, this integration has vanished in all but select inner-city neighborhoods. Even minor trip purposes, like convenience grocery shopping, school, or recreation now involve private vehicle travel. And employment or desired shopping opportunities may lie on the other side of the metropolitan area. Ironically, this new environment, which was motivated by a desire to produce a less-intense, more human-oriented place to live and raise families, has instead produced natural barriers to the types of human-scale activities that spawned them: it is very difficult to walk or bike -- except for calculated recreation -- in the U.S. suburb.

- <u>Access and Circulation within Activity Centers:</u> The method by which a traveler reaches a destination is only one dimension of the travel decision process. The challenge presented to the individual is whether they may accomplish other basic needs once at that site without the aid of a private vehicle. If the person has traveled to a downtown core area, it is generally possible to accomplish such needs as banking, domestic errands, eating lunch, or even accomplishing related business either by walking or by taking local transit. Clearly, in most suburban retail or employment centers, this is not the case. Once arrived at the site, the person is effectively isolated from any other activities without a private vehicle; thus the decision of whether or not to travel by private vehicle to the site is as much dependent on conditions once at the site, as those between home and the site.

- <u>Site Design Limitations:</u> Even at the individual site level, building designs are uninviting and inhospitable to pedestrians, cyclists, and users of transit. Particularly in suburban areas, it can be particularly challenging to reach an employment site or retail center by these modes. Suburban business parks are often isolated from all other residential or commercial activity, have expanded distances between adjacent buildings and between the building and the transportation system. The only convenient entry is via the employee parking lot, which usually is quite different from where one might arrive by transit, bike or on foot. Similarly, commercial and retail activities located in shopping centers are oriented almost exclusively to the private automobile, and are threatening and uninviting to users of any other mode.

4.3.1.2 Subjective Factors

While factors based on *the individual* certainly have an important affect on mode choice decisions as regards biking or walking, they are not as easily modified in a structured way through public policy changes. Hence, not much time will be devoted to their exploration here; the reader is referred to the Goldsmith case study for a thorough treatment of these factors.

Demographic Characteristics

Goldsmith presents data which profile the bicyclist who commutes as young, of modest income, and who is in good physical condition and enjoys exercise. While equivalent data are not presented on pedestrians, it is unlikely that pedestrians share such a uniform profile. It is argued that not as great a physical demand or exposure risk is posed to would-be walkers as is the case with bicycling, hence one would expect pedestrians to more uniformly cover the range of age, health and income brackets.

Cycling appears to be most popular to those in their mid-twenties, and use of bikes for commuting declines rapidly after age 45. At least two-thirds of commuting cyclists in a Harris poll (Bicycle Magazine, April 1991) were under age 45. The poll suggests that cycling also falls off directly with higher income, as illustrated in the following table:

Annual Income	Percent Commuting by Bicycle
$7,500 or less	23.1%
$7,501 to $15,000	14.0%
$15,001 to $25,000	5.7%
$25,001 to $35,000	6.7%
$35,001 to $50,000	1.1%
Over $50,000	7.2%

What is interesting in these figures is that cycling rates pick up again when income exceeds $50,000 per year, suggesting motives related to factors other than economic, such as exercise or environmental concerns. Goldsmith presents data from five cities which indicate that *exercise* is the top reason for commuting by bike, followed by *enjoyment, environmental concerns, and cost savings.*

Attitudes and Perceptions

Totally apart from the rational, economic factors that influence travel decisions, travel demand studies acknowledge that individual attitudes and perceptions play an important role in choosing to use alternative modes. With regard to biking or walking, there are several factors which seem to have special influence in directing choices:

- Safety

  Safety frequently emerges from travel surveys as a major concern when individuals consider biking or walking, and perhaps to a greater documented extent with biking. This relates primarily to conflicts with vehicular travel, but may also apply to concerns about safety from crime in situations where the pedestrian, or cyclist, may feel greater exposure to crime potential than if using a private vehicle or transit.

- Convenience

  Convenience is a commodity frequently attached to travel modes, which represents a variety of things to the consumer, such as ease of access, "goes when you want it to go", ease in changing direction or purpose of travel, package carrying ability, etc. To many people in travel surveys, biking or walking are not seen as "convenient" as, say, driving one's own vehicle.

- <u>Peer Group Acceptance</u>

  To a lesser extent with walking, bicycling is not accepted as a legitimate travel mode in some professional and social settings. Peers may regard the user as eccentric in his beliefs and behavior. Some may see biking or walking as a socioeconomically inferior mode, since private vehicle ownership and use has traditionally increased with level of economic status.

- <u>Habits</u>

  Finally, habits are a reinforcing decision factor unto themselves. When one chooses a particular form of behavior, it is hard to shift to another behavior just because of force of habit. This choice is further reinforced by the tendency of individuals to continuously rationalize their behavior based on experience with positive factors which are held up against the known negative factors associated with the other alternative.

4.3.2 Strategies to Alleviate Barriers to Biking and Walking

In light of the factors outlined in the previous section, the challenge in bringing about increased utilization of biking and walking for commuting and other purposeful travel comes down to identifying strategies which can help reduce or eliminate the barriers posed by these factors. Some of the more tangible strategies are listed and described below.

What becomes clear in considering the factors that impede biking and walking is that, in general, these modes are not ones which have been considered seriously in the planning and design of the current urban environment. Because of the dominance of the motor vehicle in the scale and shape of the post WW II (suburban) landscape, it becomes difficult to bike or walk to any serious activity unless (1) the person is individually determined to do so, or (2) they happen to have fallen into a relatively rare situation where the opportunity to bike or walk simply presents itself. These conditions are not likely to be reversed easily or overnight. And it is certainly not the case that conditions in the natural environment -- topography, geographic barriers and climatic extremes -- can be completely overcome in a manner suitable to full-time biking or walking. However, there are ways in which important inroads can be made into alleviating some of these barriers, both man-made and natural.

4.3.2.1 Improving Current Access and Routing

Clearly, the biggest overall impediment to biking or walking is reasonable *distance*, measured in terms of location of activities, directness of routing, terrain, and assurance of safety. In the short run, the location of activities will be as they are, guided by current planning and development trends. Thus, the short run goal is to maximize access to existing activity locations through facilities, strategic routing, and attention to traffic interactions. These include strategies such as the following:

- Sidewalks: In most suburban environments, even short distances can be threatening due to the lack of sidewalks or other trails/passageways within residential subdivisions, or which connect subdivisions with activity centers. This omission requires pedestrians to share busy streets and roadways with motor vehicles. Empirical data do not conclude directly that the absence of sidewalks in suburban areas is the prime factor in low walk rates; it is just a strong association that shows that suburbanites walk less and also have considerably less sidewalk coverage than people in cities. While the cost of installing sidewalks on every street might be prohibitive as a strategy to encourage greater walking, compromise approaches which place sidewalks or trails in strategic locations that connect activities and minimize round-about paths could be very effective.

- Bike Lanes/Trails: As with sidewalks for pedestrians, bicyclists must also vie with motor vehicles on existing streets. The 1991 Harris Poll for Bicycling Magazine showed that *having safe bike lanes* was the number one rated factor in the decision whether or not to bike to work: 49 percent of all active riders and 20 percent of all adults made such a claim. Other surveys seem to confirm this conclusion, though to varying extents.

  Alternatives to providing such facilities include dedication of lane space along the shoulders of streets or highways, or development of exclusive hiker/biker trails which connect residential and activity centers. Obviously, the quality of the bike facility also determines the associated travel time, which affects the overall willingness to bike as well as how far bicyclists are willing to travel.

- Directness of Routing: In addition to the absence of secure, dedicated facilities, bikers and pedestrians are further impeded by the fact that bike/walk connections are not particularly "direct." Thanks to typical suburban development patterns, such as residential cul-de-sacs, and arterial/collector roadway systems (as opposed to urban grids), it is difficult -- sidewalks or not -- to find a direct path from home to a destination. Existence of freeways, rivers or railroad rights-of-way also represent potentially significant obstacles. This makes the "effective distance" of a bike/walk trip even longer. Thus, it is not only important to consider sidewalks and lanes/trails for pedestrians and bikers, but these facilities must also be designed to overcome obstacles to directness. Remedies to these problems include special crossovers or tunnels, or thoughtful blending of sidewalks/trails into neighborhood and subdivision plans.

Many current hiker/biker trails are located in recreational areas which do not connect well with employment or commercial centers. Also, a metropolitan area may have major discontinuities in its regional system of paths and trails, where certain portions of the region are conspicuously not connected with the system. Alleviating these larger-scale gaps requires better regional planning and inter-governmental cooperation.

- Overcoming Traffic Conflicts: While sidewalks and trails help reduce a primary discouragement to walking and biking, by separating motorized and non-motorized travel segments, more subtle conflicts still exist. These include high relative rates of speed between motorized and non-motorized travel groups, limited crossing opportunities, and "auto-first" signalization, intersection design and enforcement policies. These important conflict problems can be greatly mitigated by thoughtful placement and design of crossing facilities, physically separated crossings where possible, and active enforcement against vehicular violations. It may also be desirable to consider traffic "calming" techniques to reduce the perceived safety threat, particularly in bike/pedestrian heavy areas; these measures can include reduced speed limits, speed bumps and stop signs on heavily travelled "through traffic" collector streets, and revised signal/turning patterns (such as elimination of right turn on red at certain times).

4.3.2.2 Improving Support and Connections with Other Modes

Relatively short-run types of changes in policy and planning related to connections at the destination and with other modes can also enhance the environment for non-motorized modes. The following strategies can produce important changes in bike/walk potential and contribution.

Intermodal Connections

While bike and walk travel may be limited by distance when they are considered as a primary mode, bike and walk loom as very important modes when used in a complementary capacity to other alternatives. In particular, biking and walking may be cost- and environmentally- effective ways to allow more people to access transit (or rideshare options) for longer trips. Methods to improve this interaction include:

- Enhanced Bike/Walk Access to Transit: A high-quality transit system is ultimately limited by the efficiency with which people can get to and from it at either end of their trip. For trips whose beginning or end is in a suburban area, access and egress is generally accomplished by feeder bus, or by auto through park-and-ride lots. Seldom are these facilities made easy to access and use by walking or bicycle, and in fact may be located away from areas where bike/pedestrian access is at its best because of the need to acquire land for parking spaces. These problems can be mitigated through construction of sidewalks and trails to reach rail transit stations (as well as better location and planning/layout of the stations themselves), and through better planning of bus transit circulation patterns and stops through neighborhoods, coupled with strategic sidewalks and short-cut paths.

- Supporting Facilities and Services: Once at a transit stop/station or rideshare staging location, the traveler also benefits from having appropriate supporting facilities, such as passenger shelters and, for bicyclists, safe and secure storage facilities. Vandalism and theft are major concerns to persons who would use bikes to connect with transit.

  Another option is to allow bike users to carry their bike with them via transit to the destination, since they may well have an equivalent problem with access on that end as well. Some transit systems have experimented with allowing the user to bring the bike on-board, or mounting it outside on a rack. Another alternative is for bike users to have a dedicated bike at both ends of the line, with secure storage for a personal vehicle or easy access to a "loaner". A transit shuttle or circulator system at the destination could also help alleviate barriers to accessing transit by bike at the origin of the trip.

Support at the Destination

As with needing appropriate handling facilities to transition from bike/walk to transit at modal change facilities, equally important are having adequate facilities at the destination end of the trip. Particularly in commuting situations, it is helpful to have bike lockup facilities and lockers and changing facilities at the site. It is difficult to ride or walk for 20 or more minutes to a work site, particularly if climatic or topographic conditions make that activity strenuous, and not have a place to shower or change. Increasingly, employers are being asked by municipalities to install such facilities as part of employee commute management programs (or are doing it on their own). Municipal governments can also help with provision of appropriate bike lockup facilities at activity centers.

4.3.2.3 Land Use and Site Design

At the root of the list of man-made impediments to biking and walking, the modern suburban, low-density environment poses inherent, structural impediments and barriers to non-motorized travel. The scale and layout of current metropolitan areas is such that travel by anything other than private vehicle seems inappropriate.

While changing these features, if it happens at all, will be a long term proposition, it is possible to outline actions that could be taken, even some that may have impact in the near future.

- Integration of Functions: As earlier discussed, the modern environment separates economic functions in land use patterns. Employment is located in one place, residences in another place, and commercial/shopping activity often in still another place. This was considered something of an early planning success in that it accomplished the separation of noisy, frenetic, (and historically dirty) employment activity from a quiet, open, and green space where people can live. Unfortunately, these land use patterns place great dependence on private vehicle mobility, which leads to traffic and related problems.

  Suburban land use and development forces will be very difficult to reverse, since they are so heavily ingrained into American lifestyle and local zoning and economic development patterns. However, there are ways in which these suburban patterns can be selectively and intelligently softened/adapted to allow for greater freedom of choice. Actions could include building convenience shopping and services in more accessible form and distances to residential development than conventional strip shopping centers. Communities can also attempt to lay out their neighborhood and activity patterns such that walking and bike facilities can be designed into the planning and construction of subdivisions before they are pre-emptied by monolithic land uses.

- Access and Circulation within Activity Centers: As earlier discussed, once at a destination/activity center a traveler still faces another set of circumstances which impact on mode choice, namely, are they "stranded" without a private vehicle? This impacts upon both the decision of whether to bike, walk or take transit or rideshare to the site in the first place, as well as whether you can exist at the site without a private vehicle for errands and other purposes once that choice is made.

  Whether or not a site possesses this characteristic is often referred to as its "pedestrian friendliness". Activity centers can alleviate this problem by first providing a more diverse mix of services and activities within reasonable distance of one another. Also important is where transit service/stops are located relative to the site activities. It is then equally important to ensure convenient access to these activities through either sidewalks/trails, or local transit circulator systems. Obviously, it is easier to accomplish this type of environment if it is designed in from the start, from the master planning through the development review process. However, even existing situations can be improved upon through creative in-fill of services, functions and facilities as growth opportunity presents itself.

- Site Design Limitations: Also discussed above, individual employment sites are often uninviting and inhospitable to pedestrians, cyclists, and users of transit, particularly in suburban areas. These characteristics also can be affected positively by improved land use planning, development review, and even employer and merchant based programs that are more visionary than present practice. Local governments can have a greater influence on where buildings are located, allowable building setbacks, and site design standards. Land owners and developers can give greater thought to location of entrances and facilities relative to transit and non-motorized access.

4.3.2.4 Travel Cost

While cost savings, *per se*, are not often shown by surveys as a major factor in deciding to bike or walk, much of this is predicated on the relative importance of other factors -- like sheer distance -- and the current relationships among modes as masked by known private and public subsidies toward the automobile.

Travel demand theory suggests that cost is a determinant in modal choice; all depends on the relative level of costs among alternatives and the relation with other factors. Said another way, there are instruments which can dramatically affect the appeal of biking or walking -- given that it is a physically-realistic option -- from a cost perspective. They include:

- Direct subsidies to persons who bike or walk to a work site, such as are offered to users of transit, or conveyed through vanpooling programs. Equipment rebates and indirect strategies such as time off with pay are also possible approaches, but with less demonstrated impact.

- Transportation allowances coupled with equivalent charges for parking for private vehicles.

- Fees of some consequence on users of private vehicles, either through workplace parking surcharges, or public sector taxes, tolls or fees.

4.3.2.5 Personal Factors

Obviously, not much can be done to change the individual to better dispose them toward biking or walking. The travel alternative simply must offer a tangible enough benefit in comparison to driving that the individual's perceptions, attitudes and behavior are altered. As with all alternative mode initiatives, attempting to change attitudes and perceptions through heightened marketing, promotion and education programs may produce results, but realistically those results will be marginal. Given, however, that efforts are made to implement any of the strategies listed above, conditions for biking and walking should become relatively more favorable. It would then be important to apprise consumers of these new options and the benefits they represent. Marketing, promotion and education programs under these circumstances would be expected to produce more than marginal results, and in fact be of considerable importance in raising traveler awareness of the new options.

4.4 EXAMPLES

This section provides some examples of programs where bicycle and pedestrian use have been encouraged through measures such as have been outlined above. They begin to give some perspective to the possibilities that exist with structured approaches to bike/walk programs.

4.4.1 Cross-Section of Bicycle Cities

Goldsmith compiled basic information on 20 different metropolitan areas, describing both their rates of bicycle use for commuting and their geographic and infrastructure features that may influence biking. These cities are shown in Table 4-4, and span the full range of possibilities with regard to size, commitment to bike-supportive measures, and rates of bicycle use for commuting.

Goldsmith analyzes these data in Case Study No. 1 to evaluate the relative importance of the following types of factors in bicycle commuting rates:

- Area Size, as measured in both land area and population.
- Density, in persons per square mile.
- Compactness, as measured in terms of percent of the population with commutes of five miles or less.
- Environmental Factors, including average temperature, rainfall, and character of terrain.

TABLE 4-4
Bicycle Commuting and Environmental Factors in Cities Across the U.S.

	Davis	Palo Alto	Boulder	Eugene	Gainesville	Orlando	Madison	Raleigh	Minneapolis	Pittsburgh
Population	55,000	56,000	80,000	106,000	140,000	166,000	190,000	212,000	358,000	370,000
Area (sq.mi.)	8	25	27	35	35	71	58	91	58	55
Pop. Density	6,875	2,240	2,985	3,029	4,000	2,338	3,276	2,330	6,172	6,727
Mean High Temperature	73.7	69.0	65.3	63.3	81.4	82.8	56.1	70.3	54.2	59.9
Days 0.1"+ Precipitation	47	38	51	138	75	118	118	112	114	153
Terrain	Flat	Flat	Mostly flat	Flat +hills	Flat	Flat	Flat + hills	Mildly hilly	Flat	Rolling hills
Total Mi's.Bikeway	56	42	39	60	102	5	33	50	46	20
Mi Bike Lane	31	35	14	38	75	0	13	10	6	10
Mi Bike Paths	25	7	25	22	0	5	20	40	40	10
Bike path/Bikeway Miles	0.45	0.17	0.64	0.37	0.00	1.00	0.61	0.80	0.87	0.50
Mi's of Street	106	N/A	280	427	400	430	587	806	1,078	800
Arterial/Collector Miles	33	N/A	116	126	125	N/A	210	N/A	306	248
Mi's Bkwy/Mi Street	0.528	N/A	0.139	0.141	0.255	0.012	0.056	0.062	0.043	0.025
Mi.Bkwy per Sq.Mi.	7.0	1.7	1.5	1.7	2.9	0.1	0.6	0.5	0.8	0.4
Mi's Bklane/Mi Arterial	0.939	N/A	0.121	0.302	0.600	0.000	0.062	N/A	0.020	0.040
Avg. Commute	3.0	11.0	5.1	4.0	4.0	12.0	7.2	N/A	7.0	6.0
% Commute < 5 miles	68.0%	N/A	77.0%	N/A	N/A	22.0%	56.0%	N/A	35.0%	N/A
% Bicycle Commute	25.0%	2.6%	9.3%	8.0%	10.0%	0.5%	11.0%	0.2%	2.0%	0.5%

	Tucson	Portland	Seattle	Washington	Phoenix	Dallas	San Diego	Ft.Lauderdale	Chicago	New York
Population	403,000	435,000	516,000	628,000	1,000,000	1,000,000	1,000,000	1,300,000	2,800,000	7,300,000
Area (sq.mi.)	156	137	86	63	424	390	331	411	228	322
Pop. Density	2,583	3,175	6,000	9,968	2,358	2,564	3,021	3,163	12,281	22,671
Mean High Temperature	81.7	62.0	59.7	66.4	85.0	76.9	70.5	83.5	58.7	62.2
Days 0.1"+ precipitation	52	149	158	112	35	78	43	80	126	121
Terrain	Flat to rolling	Some hills	Hilly	Flat	Flat	Flat	Flat	Flat	Flat	Flat
Total Mi's.Bikeway	73	76	54	44	59	42	113	33	18	94
Mi Bike Lane	67	40	15	2	59	0	93	17	0	45
Mi Bike Paths	6	36	39	42	0	42	20	16	18	49
Bike path/Bikeway Mi's	0.08	0.47	0.72	0.95	0.00	1.00	0.18	0.48	1.00	0.52
Mi's of Street	1,751	2,092	1,394	1,102	3,802	6000	2,519	3,900	3,676	5,585
Arterial/Collector Miles	509	490	477	433	977	N/A	711	834	989	2172
Mi's Bkwy/Mi Street	0.042	0.036	0.039	0.040	0.016	0.007	0.045	0.008	0.005	0.017
Mi.Bkwy per Sq.Mi.	0.5	0.6	0.6	0.7	0.1	0.1	0.3	0.1	0.1	0.3
Mi's Bklane/Mi Arterial	0.132	0.082	0.031	0.005	0.060	0.000	0.131	0.020	0.000	0.021
Avg. Commute	10.6	6.6	9.0	8.5	9.0	N/A	10.6	8.0	12.6	N/A
% Commute < 5 miles	32.0%	40.0%	40.0%	N/A	34.7%	N/A	32.0%	N/A	40.0%	16.0%
% Bicycle Commute	3.5%	2.0%	2.3%	0.5%	2.4%	0.2%	1.6%	0.8%	0.7%	0.2%

Source: Goldsmith, S.A., *Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes*, FHWA Study Case No. 1, 1993.

- Infrastructure, as measured in lane miles of highways.

- Level of Priority Treatment given to Bicycles, as measured in lane miles of bikeways.

In working with these data, Goldsmith reached the following conclusions:

- Size: Whether in terms of land area or population, larger cities tend to have lower rates of bicycle commuting. What seems to matter more than size is whether the city is a "university town", i.e., one where there is a substantial university population and subsequent impact on land use and residential patterns, population and lifestyle. The university towns included in the sample have an average bike commute rate of 10.6 percent, compared to only 1.4 percent for medium sized cities (under 400,000) and 1.0 percent in large cities. This dominance by university towns is totally apart from bike lane coverage and other important factors.

- Form: urban form, expressed in terms of density or commute length, did not emerge as important factors. Density did not matter, except in the case of New York or Chicago, where density seemed prohibitively high for biking. Percent of commute trips within 5 miles showed some relationship, although even in Davis, only 1/3 of those people living within 5 miles were commuting by bicycle.

- Bike Lane Coverage: A gauge of bike lane coverage was obtained by comparing the lane mileage of bike facilities to the lane mileage of arterial highways. This showed an important relationship: in cities where the ratio of bike lanes to arterial miles was less than 0.35 to 1, bike commuting averaged 0.63 percent; in areas where the ratio exceeded 0.35, the bike commute rate averaged 6.8 percent. Even if university towns are excluded from these measures, the bike commute rate is more than three times greater in areas where the ratio of lanes exceeds 0.35 than where it is below 0.35

The reader is encouraged to review these statistics in Table 4-1 and also Goldsmith's case study to develop a good appreciation for these relationships.

4.4.2 Davis, California

There are a number of university towns in Goldsmith's sample with high rates of bike use for utilitarian purposes, but none anywhere as impressive as Davis, California. Twenty five percent of all commute trips in Davis are made by bicycle. Davis is a town of 55,000 with a substantial student/faculty population at the University of California, Davis campus. Davis provides compelling evidence that it takes more than just the presence of a university to make bicycles a part of the transportation system. A survey conducted in April 1991 provides the information shown in the profile on the following page.

These data indicate that a substantial number of people from different sectors are commuting by bicycle, either as their primary mode or as their principal alternative. This can be seen as evidence that non-student mass cycling does occur, since the percentage claiming to bicycle commute in *each category* is greater than the total proportion of bike commuters in most other cities. The mere presence of a major university alone cannot by itself account for such a high proportion of active, non-student commuter cyclists. It is almost certain that these high rates in Davis are due to a set of proactive policies and programs, many of which were inspired by the decision of UC-Davis back in the 1960's to minimize the presence of cars on campus. These policies include:

	Bicycle as Primary Mode	**Bicycle as Alternate Mode**
Students	53%	N/A
UC Davis Employees	27%	31%
City Employees	6%	37%
School District	9%	46%
Private Sector Workers	7%	29%

- Construction of an extensive, 56-mile linked network of bike lanes;
- Bicycle registration requirements;
- Active enforcement of bicycle and motor vehicle laws;
- Very high parking fees at the UC-Davis campus; and

- Development patterns which enhance access to bicycling facilities and reduces reliance on the automobile.

Each of these features serves to legitimize and institutionalize bicycling as a viable transportation option. Though it is difficult to separate the effects of these programs from other features which make Davis attractive for cycling -- such as a warm, dry climate, flat terrain, a compact area, short average commutes, and a young population -- studies of comparably sized, similarly situated towns where bicycle commuting takes place suggest that active policies are the difference.

4.4.3 Boulder, CO Pedestrian Amenities

In 1991, *Walking Magazine* cited Boulder as one of America's 10 Most Walkable Cities. This is in addition to the reputation that Boulder has as a mecca for bicyclists, both competitive and -- as illustrated in the earlier Goldsmith data -- utilitarian (9.3 percent bike commute rate). According to an article in *Linking Bicycle/Pedestrian Facilities with Transit* by Michael Replogle and Harriet Parcells for the Federal Highway Administration, October 1992, Boulder has worked hard to earn its status as a pedestrian-friendly city. The *Transportation Master Plan for Boulder Valley, 1989* adopted by the Boulder City Council, set forth an ambitious goal to achieve a shift of 15 percent of all trips currently made by single-occupant vehicle to other forms of travel, such as walking, biking and transit. The *Pedestrian System Plan* states that the city and county shall improve the status of pedestrians by increasing the convenience, comfort, and safety for pedestrians. Following this plan, Boulder has made significant investments in sidewalks and pedestrian pathways, hosted an International Pedestrian Conference for the past 12 years, funded an Alternative Transportation Center and Pedestrian Systems Coordinator, and taken other important steps to make Boulder a place where people would rather stroll than drive.

There are two heavily-used pedestrian facilities in Boulder: the Boulder Creek multi-use path, which winds for four miles through the center of Boulder; and the Downtown Pearl Street Pedestrian Mall, a gathering place for shoppers, strollers and entertainers. Pedestrian needs are incorporated into the planning and design of transit facilities. At the central transit station, a person can easily get schedule information and bus passes/tokens while sitting in a pleasant environment waiting for the bus. Sidewalk connections to transit are being explored as part of the Neighborhood Transit Center Concept currently under study.

Maintenance of existing sidewalks, installation of handicap ramps and new sidewalk construction is part of Boulder's "Sidewalk Program" designed to bring Boulder's sidewalks up to code in an efficient and effective manner. The program is estimated to cost approximately $11 million over 7 years. The City's Alternative Transportation Center, known as GO Boulder for "Great Options", has developed and begun to implement an innovative comprehensive marketing program designed to change citizen's mobility habits. The program seeks to educate the public of their mobility options and encourage their usage of alternative modes of transport.

4.4.4 Portland, Oregon's Livable Downtown

Portland is a city that is somewhat unusual among its peers. While downtown Portland was subjected to the same forces of suburbanization and urban decay that plagued most larger cities during the 1960's and 70's, it has managed to re-establish its strength and character as a regional center -- not only of commerce, but of people and culture as well. Today, 43 percent of the people who work downtown arrive by transit, another 5,000 arrive by bicycle, the streets are relatively uncongested, and pedestrians enjoy a high level of mobility (*Portland's Livable Downtown*, Surface Transportation Policy Project Case Study).

The transformation of Portland back to a livable city was a conscious act of the city's leaders and citizens. In 1972, the city leaders made a bold decision to turn away from the use of the automobile and improve on what they already had -- a walkable downtown. Because the city had been substantially developed before the era of the automobile, it had the natural makings of a pedestrian-friendly environment: small blocks and a grid system of streets. As part of the city's new policy, street widening in Portland was stopped, as was new parking lot construction, and a proposal for a new freeway was scrapped in favor of a light rail system. Nearly a mile of downtown streets was closed to traffic and the space redesigned into parks, parkways and pedestrian malls. An additional mile of streets was transformed into people-oriented transit areas by narrowing four-lane streets to two lanes and widening the sidewalks. On many of these streets, a lane was subsequently dedicated to transit. Special paving and landscaping was added to make the areas more attractive and street vendors were licensed to open cafes, sell flowers and offer entertainment.

As part of the plan, considerable thought was also given to making transit service attractive and available. As part of its clean air attainment plan, the city improved downtown circulation by designating a fare-free travel zone through the heart of the downtown. A light rail system -- the Metropolitan Area Express (MAX) -- went into operation in 1986, and has been (actively or passively) credited with substantial land use reorientation both in and outside the city. By choosing to invest in its transit and downtown shaping program, Portland estimates that it has been able to avoid construction of two lanes per arterial entering the downtown.

Another key aspect of the Portland strategy of making transit and walking more appealing was to make driving less appealing. In 1972 the City placed a permanent cap on parking. Since that time, 30,000 new jobs have been created in the downtown, though the City has added no new parking that wasn't in the 1972 plan.

In lieu of the transit and parking measures, local officials estimate that nine new 42-story parking structures would have been needed downtown.

The result of the City's leadership and vision is a healthy and thriving economy that is expected to grow dramatically in the next two decades: it is estimated that by 2010, one newcomer will settle in Portland for every three now living there. To accommodate this growth without sacrificing the current quality of life, the Portland Planning Bureau developed its Livable City Project, which features the following additional elements: increasing the supply of low-rise housing in the downtown; creating compact urban villages around transit stations; increasing commercial uses along main streets; and filling in existing residential neighborhoods and creating compact neighborhood development on unused tracts of land, such as abandoned commercial properties.

A transit-land use connection appears to be more than just planning theory in Portland. It has become a demonstrable strategy for not only moving people, but a working method for guiding growth and protecting quality of life.

4.4.5 Examples of Bicycle/Pedestrian Linkages with Transit

As discussed earlier, another key contribution of bicycling and pedestrian modes is to make public transit service more effective; in this way, bike and walk are not just limited to people who can make relatively short trips, but are key elements in an intermodal system. Transit studies routinely show that people are unwilling to walk much more than 2 blocks or 1/4 mile to reach transit, which becomes a particular impediment in suburban areas where it is difficult to provide transit coverage which brings service this close to the average home. The alternative is generally to build parking lots so that people can first drive to transit, contributing to localized traffic congestion and air pollution. Finding more creative ways to allow people to access transit by non-motorized modes can be an effective way of increasing overall transit usage and also reducing localized travel problems.

There are a number of strategies which are being used to improve bike/pedestrian linkages with transit. A very thorough report on this subject which was used in presenting the examples below is *Linking Bicycle/Pedestrian Facilities with Transit*, by Michael Replogle and Harriet Parcells for the Federal Highway Administration in 1992.

- <u>Bus Stop Shelters</u>

  Areas with temperature and weather extremes can offer pedestrian passengers greater comfort and encouragement through greater use of bus shelters. For bus transit operations, where bus routes are difficult to "see", shelters can give evidence of the system's presence. Shelters cost between $3,500 and $8,000 per unit, and transit agencies can frequently finance all or a major portion of the construction and maintenance cost through private advertising revenues. Areas like Atlanta feel strongly enough about the message sent to consumers through improvements like shelters that MARTA, the regional transit agency, has embarked on a program to build 1,000 new shelters (system of 20,000 stops) over the next two years. Cities like Houston and Milwaukee already have shelter systems in place with an even greater shelter/stop ratio than Atlanta.

- Bike Parking Facilities at Transit

  Like shelters, having a safe and secure place to park a bicycle at a transit stop or station sends a message to those who would consider using bicycle to reach transit. Forging a better link to receive bicycles is important since bicycles extend the effective range of non-motorized access by several distance multiples over walking. Security of parked bikes is a major concern to bikers using transit as revealed in surveys. Options are either lockers or racks, with the lockers offering more apparent coverage/security though much depends on the construction and security of the lockers themselves. Many cheaper lockers have been a disaster (early BART experience). Those that are provided, particularly at commuter rail and subway stations, are generally well utilized. For example, BART in San Francisco has 470 usable lockers, with 350 regularly rented. CalTrain, the commuter rail service south of San Francisco, has 374 lockers with about 75 percent regularly utilized. The MBTA in Boston has racks for bicycles at 20 stations, and sees between 200 to 250 bikes on a given day at some stations. Washington Metro offers about 900 rack spaces at its Metrorail stations, and about 650 lockers which are about 1/3 rented, although wait lists exist at many stations.

- Improved Access for Bicycles and Pedestrians to the Transit Stop

  The lack of attention to the bicycle/pedestrian beyond the transit stop or station is fairly common. Many stations are located purposely in areas where park and ride lots can be most readily constructed and auto trips intercepted, which -- ironically - is also in locations which are most distant from or inaccessible to bikers or walkers. In a study of access to four Northern Virginia rail transit stations in 1988, the Metropolitan Washington Council of Governments found that 81 percent of the transit users reached the station by private auto. The study further found that 66 percent of the available spaces were occupied by people living within three miles of the stations, in effect pre-emptying use of the spaces by long-distance auto trips. The survey revealed that the major reasons why more people did not attempt to reach the stations by biking or walking were lack of suitable facilities to reach the station, danger from auto traffic, no sidewalks or inadequate lighting.

A number of areas are attempting to give more comprehensive attention to the overall travel situation faced by bikers and pedestrians in trying to use transit. The City of Charlotte, North Carolina, began a project in 1981 to encourage bike and walk access to bus transit along its heavily-travelled Central Avenue Corridor, which contains seven intersections with Level of Service of E or F in the peak hours. Pedestrian access was improved by installing 114 pedestrian signals and 115 push buttons at key intersections, and sidewalks were constructed (with curb cuts for bikes and disabled users). To address bike needs, racks and lockers were installed at key stops, with careful attention to location of rack near benches and shelters to maximize safety.

Other good examples of aggressive compressive access programs may be found in Houston, Los Angeles, San Diego, Santa Clara County, Sacramento, and the state of Florida.

- <u>Bike on Transit Programs</u>

  Two problems are faced by persons who would use transit -- access to the transit service at the home end of the trip, as well reaching the destination at the other end. One way of accommodating this problem and also alleviating some of the storage security concern of bikers who use transit is to allow the cyclist to bring the vehicle along on the transit trip. This concept has been around in some form for a number of years, first tried on rail transit systems and then tried on bus systems, where the bike is loaded into an outside rack. Generally, the bike user is required to purchase a permit for the privilege, although the permit is usually attractively priced ($3 to $5), and is valid for a long period, often a year or more. Also, generally, the privilege is not available during the congested peak hours, but only off-peak and on weekends.

  At least five U.S. Commuter rail systems allow bikes-on, including the Long Island Railroad, MBTA in Boston, and SEPTA in Philadelphia. And at least 12 rapid rail and light rail U.S. systems have bike on rail programs. At least 18 American bus transit systems have instituted bike on bus systems, with good examples being San Diego (Coronado Bridge crossing route) and AC Transit's Pedal Hopper in Oakland, California.

4.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

This section takes a *parametric* approach at estimating what the impacts would be on vehicle trips and travel of higher bicycle and pedestrian utilization rates for utilitarian travel. It is difficult from the empirical data at hand to suggest that particular types of pedestrian or bicycle improvements or program measures will have a predictable quantitative effect on travel behavior. It is perhaps more telling, instead, to look at current rates of bicycling and walking and see what the effects would be on vehicular travel if higher bike/walk rates were somehow accomplished, particularly for commute trips, which is when traffic congestion and highway capacity problems are at their worst, and when bicycle (particularly) and walk rates are at their lowest among all trip purposes. The practitioner or policy maker can then deliberate on whether it would be worthwhile to consider closer evaluation or greater implementation of bike/walk measures in their particular situation.

To set up such an analysis, the following questions are posed:

- What are current rates of usage of bicycling and walking in urbanized areas, particularly for commute trips (i.e., what portion do they make up of total commute travel, and of total travel)?

- In what travel market, in terms of trip length, are bike and walk trips potentially viable substitutes for vehicle trips?

- What would higher use rates of bike or walk mean in terms of total regional commute and daily travel?

This analysis is best addressed, once again, through use of the 1990 NPTS data. The NPTS indicates that total daily person trips in urbanized areas of the U.S. was approximately 134,360 million trips in 1990, of which 87.1 percent were made by private vehicles, accounting for 690,850 million daily vehicle miles of travel (VMT). Commuting alone accounts for 31,580 million person trips, of which 89.3 percent are made by private vehicle, generating 252,320 vehicle miles of travel. Thus, commuting accounts for only about 21 percent of daily person trips, but 36.5 percent of daily VMT (commuting trips have the longest trip length of all trip purposes, and the lowest vehicle occupancy rate at 1.1 persons per vehicle).

Walk trips account for 7.2 percent of all daily trips, and 4.5 percent of commute trips in urbanized areas. The average trip length of a walk trip is 0.7 miles, slightly longer for commute trips at 0.9 miles. Bicycle trips account for 0.7 percent of all daily trips, and 0.4 percent of commute trips. The average trip length of a bicycle trip is 1.8 miles, again slightly longer for commuting at 2.1 miles. Within a radius of 5 miles, both walk and biking have higher shares of commute (and other) travel. For commute trips of 5 miles or less, approximately 9.2 percent are made by walking and 0.8 percent by biking -- about double the rates for the overall region. However, while commute trips of 5 miles or less make up 47.3 percent of all person trips in urbanized areas, they contribute relatively little, 12.4 percent, to total regional commute VMT. Hence, making bicycle and pedestrian inroads to higher commute rates would be expected to have its primary benefit in the reduction of vehicle trips, per se, and not VMT.

Analysis of these hypotheses is played out in Table 4-5. The table indicates what the impact would be on regional commute trips and VMT, as well as total daily vehicle trips and VMT, of increasing the share of walk and bicycle above current levels. These current levels are 4.5 percent of total commute trips for walking, and 0.4 percent of total commute trips for bicycle.

TABLE 4-5

EFFECT OF INCREASED WALK/BIKE USE ON TRAVEL

	Walk	Bicycle
Current Share of Commute Trips	**4.5%**	**0.4%**
Increase Share by 1%		
New Share	**5.5%**	**1.4%**
Reduction in:		
Commute Trips	0.5%	0.9%
Commute VMT	0.1%	0.2%
Total Trips	0.1%	0.2%
Total VMT	<0.1%	0.1%
Increase Share by 2%		
New Share	**6.5%**	**2.4%**
Reduction in:		
Commute Trips	1.4%	1.8%
Commute VMT	0.2%	0.5%
Total Trips	0.3%	0.5%
Total VMT	<0.1%	0.2%
Increase Share by 5%		
New Share	**9.5%**	**5.4%**
Reduction in:		
Commute Trips	4.1%	4.1%
Commute VMT	0.4%	1.1%
Total Trips	0.9%	0.9%
Total VMT	0.2%	0.4%

If the share of both modes is increased by 1 percent, to 5.5 percent for walk and 1.4 percent for bicycle, the effect would be to reduce regional commute trips by 0.5 percent for walking and 0.9 percent for
bicycle (bike has larger impact because the 1 percent increase is larger relative to its starting share -- both would have the same rate of vehicle trip reduction impact. The effect is much less for VMT, since the trip lengths which are being affected by bike or walk are relatively short, i.e., 1 to 2 miles. The reduction in VMT would be 0.05 percent for the 1 percent increase in walking and 0.24 percent for the 1 percent increase in biking (biking would reduce proportionately more VMT because its trip lengths are approximately twice that of walking). These trip and VMT reductions in commute travel would have their greatest effect in peak hours, when relief from traffic congestion is most desired. The effect on total daily trips and VMT is much less, as shown in the table, since commute trips are only 21 percent of daily trips, and commute VMT is only 36.5 percent of daily VMT.

The table also shows the trip and VMT impacts that would result from 2 percent and 5 percent increases in bike and walk share. The 5 percent increases, if combined, would produce an 8.2 percent reduction in commute vehicle trips and a 1.5 percent reduction in commute VMT. One asks: are these levels of bike/walk utilization achievable, and do the results justify the effort? To answer the first question, increases in bike/walk percentages to 5.4 percent and 9.5 percent, respectively, may seem high, yet it should be noted that (1) there are metropolitan areas that have current rates many times higher than these, and (2) little if anything is currently being done in most metropolitan areas, in terms of planning, facilities and programs, to encourage consideration and use of these modes. Planning for bike or walk access in suburban developments is virtually unheard of, as is the budgeting and construction of sidewalks or trails to provide the fundamental basis for persons to try these modes (revisit the Cobb County example in Section 2).

In terms of whether the results justify the commitment and effort, this is also a two-part answer. While bike and walk travel does not appreciably affect near-term VMT, it does reduce vehicle trips. In terms of air quality, the majority of a vehicle's emissions are generated in the first 5 of its drive cycle, when it is in "cold start" operation. Thus, eliminating the start of the vehicle is highly important from an air quality point of view. From a traffic view, using the Cobb County example once more, the diversion of a reasonable percentage of short trips in congested activity centers, which would have been made in private vehicles, can have obvious benefits on localized travel conditions, even though the longer trips are not shifted to bike or walk. The second part of the answer, however, as to whether these shifts are worthwhile, may be justified by the longer-term implications. If changes are made to the existing environment to support higher levels of bike/pedestrian travel, then changes are being made that also change that environment in more fundamental ways that are favorable to transportation management. Namely, this implies: better balancing of and coordination between land uses, and providing linkages between activities such that overall dependence on private vehicles for mobility *once at a site* are much less. So the longer term success prospects of TDM and air quality management are both served by environments which have greater appeal to cyclists and pedestrians. The next section discusses some of the economic rationale behind supporting bike or walk programs.

4.6 COST EFFECTIVENESS

In Part III, *Synthesis of Findings*, of this report, a methodology is developed which portrays the cost effectiveness of TDM in relation to Society, Employers, and Individuals. This section applies several of these relationships and the methodology to the assessment of the cost effectiveness of bicycle/pedestrian programs.

The cost effectiveness analysis in Part III develops figures which suggest that the average cost to Society of accommodating an additional person trip for commuting in a Single Occupant Vehicle (SOV) is $6.75 per one-way daily trip, or $13.50 per day. This corresponds to the cost to construct and maintain additional highway capacity to accommodate a marginal vehicle trip for commuting purposes on an already-crowded peak period highway. This hypothetical trip is 10.5 miles long (1990 NPTS Survey), and it is assumed that it happens over a 2-hour peak period and that the capacity is fully utilized in both directions (both cost-minimizing assumptions). These costs are attributed entirely to the peak period demand exerted by the SOV commute trip, since the capacity is typically going to be supplied to satisfy a peak period congestion problem and not demands from the rest of the day.

What are the equivalent costs of satisfying a commute trip which is made on a bicycle or on foot? Assume, as in the previous section, that the average bicycle commute trip is 2.1 miles long, and the walk commute trip 0.9 miles. Data obtained from Montgomery County, MD suggests that the cost to construct a bicycle lane/trail averages about $52,000 in 1993 dollars. Assuming, as with the highway/SOV example, that the cost of such a facility would be capitalized over a service life of 20 years, at a social rate of interest of 10 percent, then the effective cost per day would be about $23 per mile. Data from the Custis Bike Trail in Northern Virginia, a reasonably well-used facility, suggests a peak period ridership of about 80 vehicles, or 160 commute vehicles per day. Thus, the estimated cost to society of a commute bike trip would be:

$$\frac{\$45/\text{mile/day}}{160\ \text{riders/day}} \times 2.1\ \text{miles/trip} = \$.30/\text{one-way trip}$$

Placing the auto costs in comparable terms requires reducing the trip length from 10.5 miles to 2.1 miles:

$$\$6.75/\text{1-way trip} \times \frac{2.1 \text{ miles}}{10.5 \text{ miles}} = \$1.35/\text{one-way trip}$$

So this is an implied savings to society for every commute trip shifted to bike of $1.05 per one way trip, or $2.10 per day. It is clear that 40 riders per hour on the bike facility is considerably less than its capacity (SOV costs calculated at capacity), hence the bike costs could be considerably less than estimated, and the savings relative to SOV much greater. A complete analysis would also want to consider the cost of support facilities, such as bike racks/lockers at destinations, signing and signal changes, etc., and also factor in whether these costs are publicly-borne, provided by employers, or covered by user revenues.

In the case of pedestrians, the average cost of a sidewalk is about $50 per lineal foot, or $264,000 per mile. Assuming a rate of interest of 10 percent, and a service life of 30 years (longer because of less traffic and upkeep), this works out to $21 per day. Assuming the same allocation of this expense as with the bike trail to 160 daily commuters, the cost to society of supporting a pedestrian work trip would be:

$$\frac{\$21/\text{mile/day}}{160 \text{ users/day}} \times 0.9 \text{ miles/trip} = \$0.12/\text{one-way trip}$$

Placing the auto costs in comparable terms requires reducing the trip length from 10.5 miles to 0.9 miles:

$$\$6.75/\text{1-way trip} \times \frac{0.9 \text{ miles}}{10.5 \text{ miles}} = \$0.58/\text{one-way trip}$$

So this is an implied savings to society for every commute trip shifted to walking of $0.46 per one way trip,, or $0.92 per day. As with the bike trail example, it is clear that 40 pedestrians per hour on the sidewalk is considerably less than its capacity (SOV costs calculated at capacity), hence the pedestrian costs could be considerably less than estimated, and the savings relative to SOV much greater. Again, a complete analysis would also want to consider the cost of support measures like crossing facilities, signing and signal changes, etc.

The cost savings to employers amount to reduced parking costs traded off against bike lockup facilities and possibly shower and change facilities. These costs apply almost exclusively to bicycle users, while the costs to support walking may be virtually zero. Of course, employers may need to do more to achieve higher levels of biking and walking than just supply support facilities, as above. They may need to offer administrative support (coordinators, marketing, etc.), or provide financial incentives to overcome the attraction of driving. Empirical evidence on the effectiveness of these measures by employers is insufficient to perform a meaningful analysis.

The cost savings to the individual are relatively easy to compute, in that the cost of biking or walking, for practical purposes, is free. Bikers -- particularly recreational enthusiasts -- already have extensive equipment, so that their only costs are likely to be routine maintenance. To be safe, the analysis for bike commuting may use an estimate of $0.05 per mile for bicycle commuting (Bicycle Federation of America), compared to $0.45 per mile for auto travel (Motor Vehicle Manufacturers Association, 1992). For a 2.1 mile hypothetical trip, the bicycle commuter saves $1.78 per day over driving alone, more if parking carries a price at the workplace. The pedestrian is assumed to realize no cost for a trip of 0.9 mile, which amounts to a savings of $0.81 per day over driving, again assuming that there is no cost for parking. Thus, biking and walking are cost effective solutions to society at large, and to individuals.

4.7 IMPLEMENTATION ISSUES

Based on the preceding discussions, it becomes clear that stimulating higher rates of usage of bicycle and walking modes has benefits as part of an overall transportation management strategy, one which is inherently cost effective from a public investment point of view, and which favorably impacts upon air quality challenges that are facing many areas. The dilemma, of course, is that biking and walking carry some important limitations in terms of distance, shape of the environment, and even perceptions as to their suitability and practicality for non-recreational purposes. These limitations notwithstanding, there are a number of technical and policy actions which can be taken to maximize the benefits which can be offered by these modes. The following are offered as recommendations toward ways to accomplish the implementation of the more effective strategies:

4.7.1 Planning for Transportation Programs Needs to Proactively Consider the Potential Bicycle/Walking Link

Bicycle and pedestrian initiatives have typically been pushed by interest groups, rather than evolving as part of a rational, comprehensive planning process that sees biking and walking as an integral link to the overall transportation system. These linkages apply not only connections between residential areas and activity centers, but where these modes are carefully considered in relation to regional transit systems and in the design of activity centers themselves, so that they can support access and circulation by modes other than just private vehicles. The requirements of the Clean Air Act Amendments (CAAA) of 1990 and special funding sources (Congestion Management Air Quality, or CMAQ) under the Intermodal Surface Transportation Efficiency Act

(ISTEA), may well provide the impetus to broaden the consideration of these non-motorized modes in local planning and programming.

4.7.2 Direct Scarce Resources Toward Settings with the Greatest Payoff

The research results tell us that certain factors help explain where bicycle and walking initiatives are likely to be most fruitful. These include settings where travel distances are relatively short between residential areas and key trip attractors, areas where there are high concentrations of people under 40 (such as university communities), and where there already exists compatible infrastructure which can be modified into appropriate facilities. Areas where auto travel is difficult because of localized congestion or parking facilities are crowded and expensive also represent good potential, so long as the congestion does not present a safety threat to bike or pedestrian travel.

4.7.3 Place Emphasis on Conventional Facilities

Despite the intellectual appeal of bicycle and walking facilities that double as recreational trails, evidence suggests that less exotic options such as sidewalks and bike lanes along arterials are probably just as or more effective and may cost much less. For utilitarian travel like commuting, would-be bike/walk patrons are more likely to be interested in an efficient, direct path with acceptable safety levels, than one which is isolated and attractive but that does not go where they want it to go. Nevertheless, if park trails and bike paths are in existence or are planned, their recreational use may well lead to spillover to greater levels of utilitarian travel.

4.7.4 Consider Linkages which Promote Continuity

In many urban areas where systems of bike trails, paths or walkways exist, they may fall short in that there are major gaps in the network by which activities are connected. For example, a regional system of bike paths/trails may simply not be connected to particular sectors of the metropolitan area because of missing links or absence of coverage in the given area. Similarly, pedestrian paths may be blocked or truncated, or made circuitous by natural or man-made obstacles. This continuity can be improved through careful planning and identification of obstacles.

4.7.5 Think in Terms of Packages of Actions

Empirical evidence suggests that no one strategy looms as paramount in the decision to bike or walk. Obviously, safety is an issue, as is having a secure place to park one's bicycle if biking is the mode, or having a place to shower and change at the end of a long and strenuous trip, or in extreme weather. It appears more practical and promising if strategies to enhance biking and walking are done not piecemeal, but as part of a carefully-thought-through program of actions where each of the major impediments/barriers is diminished in some way.

4.7.6 Consider the Linkage with Transit

While higher percentages of commuters using biking or walking for their primary mode to work offers dividends, the potential in terms of congestion or air quality may be greater if bicycling and walking are given higher attention as supporting modes to connect with transit for longer trips. This means careful thought and design of transit stations in rail systems, to be able to attract substantial numbers of user from local neighborhoods by walking or biking, rather than cars. It also means working within the formal planning process to promote linkages between transit and the community, via path/sidewalk connections as well as avoided conflicts with traffic. And it also means attention to inter-system connections, meaning secure bike rack/locker areas for cyclists, and shelters and adequate lighting for pedestrians.

4.7.7 Private Sector Involvement and Support

Developers play an important role in the potential for bike/pedestrian use in the design of buildings and subdivisions, in terms of the location of buildings relative to streets, other buildings, services and transit. Development review procedures can and have been used successfully to force higher design standards as regards incorporation of bike/pedestrian/transit usage. Similarly, employers can be encouraged to increase attention to bike/walk use through provision of bike facilities, and showers and changing facilities; areas with municipal/regional ordinances for trip reduction/management can stimulate employer participation in these important programs.

4.7.8 Financial Encouragement

While cost, per se, is not shown by surveys as a major reason why individuals bike or walk to work, these surveys are generally measuring reaction to the status quo regarding relative costs among modes, and suggest that persons who bike/walk do so for entirely different reasons. However, substantial changes in the relationships among modes in terms of cost, such as might come about through introduction of either incentives or driving disincentives (charging for formerly free parking) would be reasoned by most travel analysts to have a significant effect on the attractiveness of walking or biking, assuming that it is a physically reasonable option. These incentives/disincentives might be motivated by the development review process, trip reduction ordinances, or state/regional/local taxes or fees levied in response to traffic or air quality goals.

4.7.9 Marketing and Education

Assuming strategies can be implemented which materially enhance the environment for biking or walking, then it will be important to notify the public of the changes and their potential benefit from seeking use of the options. These efforts should also be paralleled by monitoring and evaluation, with collection of appropriate data to track the effectiveness of particular technical, policy or marketing/informational approaches for future planning and programming efforts.

In the long-term, the ultimate potential of biking and walking depends on major alterations to current development trends, planning procedures, funding programs, and even tastes and preferences which are conditioned on current experience. Until or whenever these more fundamental changes occur, the measures listed above should dramatically increase the use and contribution available from these seldom used, time-honored modes of travel.

4.8 REFERENCES

The reader is directed to the following references for more detailed specific information on bicycle or pedestrian programs:

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B. INCENTIVES AND DISINCENTIVES

Employer Support Measures
Preferential HOV Treatments
Economic Incentives
Parking Supply and Pricing Management
Tolls and Congestion Pricing

B.1 EMPLOYER COMPLEMENTARY SUPPORT MEASURES

1.1 DESCRIPTION OF STRATEGY

Other sections of this report describe TDM strategies that encourage the use of alternatives to driving alone by reducing the cost, time, or "image" penalties associated with these alternatives. These strategies have been shown to be effective in attracting commuters away from single occupant vehicles, but their effectiveness is limited by commuters' knowledge of ability, and willingness to use the alternatives.

Driving alone is such a long-standing habit for most U.S. commuters that few even think of trying an alternative without encouragement and assistance. This section discusses how the effectiveness of TDM strategies can be enhanced by providing ***complementary*** programs and services that increase commuters' awareness of their alternatives, enhance the convenience of using an alternative, or reduce the need for a personal automobile during the work day.

It is important to emphasize that *complementary* programs and services are not "front-line" TDM strategies. Alone, their impact on mode choice will be slight, because unlike strategies that can provide tangible time or cost benefits to commuters (such as carpool subsidies), *complementary* programs do little to change the relative attractiveness of different commute modes. *Complementary* programs are, however, an integral part of a successful TDM program. Without awareness and support, few commuters will seek out alternatives and will thus continue to drive alone. The function of *complementary* programs is to support and encourage use of TDM strategies that can make commute alternatives enticing.

Complementary programs and services fall into three categories:

- TDM program marketing
- Site amenities and design
- Supporting activities

TDM MARKETING

Drive alone commuters must be made aware of the availability of TDM strategies and encouraged to try them. As a *complementary* measure, **program marketing** features dissemination of information on available TDM services and incentives to the public at large or targeted to specific travel markets. Program marketing often also includes personalized commute planning assistance and special promotional activities such as fairs or "clubs" that can increase commuters' interest in ridesharing.

As with many TDM program elements, marketing of TDM can be directed to commuters at several geographic levels: regional, local area, and individual employers. Regional marketing typically is sponsored by regional ridesharing agencies (see section 3), transit operators, local governments, and metropolitan planning organizations. These agencies often promote the use of TDM generally, but some regional programs target the use of specific regional strategies or services such as public transit. Regional commute groups increasingly are targeting their TDM marketing activities to employers because of their greater effectiveness on promoting TDM to employees.

TDM marketing can also be targeted to a smaller audience in a defined local area, for example, an employment, shopping, or residential complex. Developers and property managers are often the sponsors of these programs generally as a condition placed on the development project by a local planning board. TDM marketing in a local area can also be sponsored by groups of employers and/or developers (e.g., transportation management associations). To these groups, joint marketing could result in cost savings over individual promotion. At employment sites, local area marketing is often targeted to new tenants by the leasing agent or building manager. Residential-based programs often target new residents through realtors and property managers.

The third geographic level of program marketing is at an individual employment site. Here, marketing is done by employers who promote use of TDM options to their employees. Employer marketing efforts do sometimes include general promotion of TDM, but most often market the specific TDM services and incentives provided by the employer or options available only to travelers at that site.

There are three components of TDM marketing that warrant attention - information dissemination, transportation coordinators, and special promotions.

- *Information Dissemination* - TDM information can be disseminated by many methods depending on the scope and size of the target market. *Regional* distribution methods might include mass mailings, newspaper, radio, and television advertising, and roadside signs, such as those that list "Pool" phone numbers. At *individual employment sites*, information dissemination typically relies on posters, bulletin boards, flyers distributed desk-to-desk, in-house newsletters, new employee orientation, and periodic promotional events such as rideshare fares. *Local area* information dissemination utilizes elements of each of these other two programs, for example, mass mailings to new tenants or new homeowners, information distributed through realtors and building managers, posted notices, newsletters, and promotional events.

  Information can be provided at various levels of sophistication and commuter convenience. The most basic level is passive postings, such as carpool ridematch boards, information "take one" displays, mass mailings, and roadside signs that inform commuters of assistance available from a remote source such as a regional ridesharing agency. At this level, the commuter must make the effort to follow-up with a call or mailback card to receive more information.

The highest level of information assistance is provided by a commute information center, centrally located within an employment area, at a transit station, or at an individual employment site. At this level, the commuter still makes an effort to use the center's resources, but receives immediate, personalized assistance. These centers are staffed, generally full-time, and provide both information on available services and personalized commute planning. They also can serve as outlets for distribution of transit fare media or other commute products.

- *Transportation Coordinators* - Many commute information centers and some remote assistance offices are staffed with transportation professionals who provide personalized assistance to commuters. These professionals, often called Transportation Coordinators or *Employee Transportation Coordinators* (ETCs), offer individual trip planning assistance at employment sites, as well as performing more general marketing and information functions. At employment sites, the ETC is generally the focus of the company's commute program, and manages the program's development, implementation, marketing, administration, and evaluation.

- Special Promotions - In addition to general and on-demand information on TDM strategies, TDM marketing often includes special promotions such as periodic prize drawings, contests, awards for ridesharing, commuter or bicycle clubs, and other activities to attract the attention of commuters, generate excitement about the use of commute alternatives, and reward ridesharers. They are often sponsored in conjunction with area-wide commuter promotions such as annual ridesharing week or Earth Day. Special promotions are widely used, especially at employment sites, in part due to their low cost and high "splash" value.

SITE AMENITIES AND DESIGN

Many employment sites, especially those in suburban areas, were designed with the expectation that employees would primarily arrive by private automobile. This expectation often becomes a self-fulfilling prophecy, because the site design does not accommodate the needs of commuters who choose not to drive. The goal of the second group of *complementary* programs, site amenities and design, is to change the work site to make it more "friendly" to commute alternatives.

- *"Rideshare Friendly" Work Site Design* - "Rideshare friendly" work sites are those that: accommodate the space and maneuvering needs of transit and vanpool vehicles; provide safe, attractive rideshare loading areas; and minimize the walking distance for HOV commuters. Some sites also target the special needs of bicycle and pedestrian commuters. They include bicycle parking protected from theft and from the weather, showers and personal storage lockers, and bicycle maintenance facilities. Other elements of work site design, such as presence of sidewalks, bicycle and transit access to and within a site or neighborhood, are dealt with in Section II A.4.

- *On-Site Services* - On-site services include cafeterias and restaurants, dry cleaners, ATMs, convenience shopping, video rental stores, printers and copy shops, and other personal or business-related service establishments commuters need to perform work day errands. A common objection to ridesharing voiced by drive alone commuters is that they need a car during the day to perform personal or job-related errands. A 1991 survey of Southern California commuters, for example, showed that 29 percent of employees make at least one errand stop on the way home from work. Over half of the commuters also said they need their car for business or personal trips during the midday. (*State of the Commute,* Commuter Transportation Services, Los Angeles, CA, 1991.) Many of these stops and trips were for meals or shopping. Availability of service establishments on-site or within walking distance can minimize both the true and perceived need for a personal auto.

SUPPORTING SERVICES

Supporting services are program elements that address two concerns that commuters often have about use of commute alternatives: the fear of being stranded without transportation in the event of an emergency, and the fear that use of ridesharing will hinder their advancement in the company.

- *Guaranteed Ride Home Programs* - Guaranteed ride home (GRH) programs, also called guaranteed return trip or emergency ride home, are "commuter insurance". Many commuter surveys have shown that an important factor in commuters' reluctance to rideshare is the fear they will not be able to respond to a personal emergency, such as picking up a sick child at school, or be stranded without transportation if they have to work late unexpectedly. GRH programs offer free or subsidized emergency transportation, generally by taxi cab or rental car, to commuters who do not drive to work alone.

- *Corporate Commitment* - Corporate commitment refers to the overall level of support for the TDM program. In general, it reflects a willingness of upper level corporate management to devote resources to the program, provide tangible incentives, establish a corporate "culture" that supports (rather than penalizes) employees' use of commute alternatives, and participate in local and regional transportation-related programs. A strong commitment typically is demonstrated by an extensive package of incentives offered to commuters, but also includes supportive work environment policies such as not holding meetings late in the afternoon and not penalizing ridesharing employees who choose not to work overtime. Strong corporate commitment is sometimes manifested by ridesharing among corporate executives.

1.2 NATURE OF EFFECTIVENESS

Complementary programs **support** mode shifts to ridesharing rather than **causing** the shift. Their influence on mode choice often comes after tangible economic incentives or disincentives have motivated the drive alone commuter to consider alternatives to driving alone. They encourage further consideration of ridesharing by removing secondary impediments to ridesharing. Some of the impediments they address are real, but many are perceptual and/or psychological impediments to giving up a personal automobile. *Complementary* programs can also provide encouragements to give ridesharing a try or psychologically reward commuters who do not drive alone.

One real ridesharing impediment, addressed by information dissemination, is commuters' lack of awareness that options to driving alone exist and that employers, developers, and regional agencies provide incentives for commuters' use of the options. Surveys suggest, for example, that *many commuters are unaware of specific commute services and incentives that are available to them* (*Internal Employee Surveys* conducted at State Farm, Irvine, CA, 1991; National Institutes of Health, Bethesda, MD, 1989; and Warner Center, CA, 1990).

Increasing awareness of such services could lead to an increase in commute alternative use by those commuters who are receptive to a shift to an HOV mode, but need information on ridesharing partners or transit service. This is borne out by a 1990 survey conducted in Warner Center, a suburban Los Angeles office park. Nearly 20 percent of the respondents who had begun ridesharing during the previous year indicated that "help finding people with whom to carpool" or receiving "bus route and schedule information" was important in their decision to rideshare (*1990 Survey Findings and Program Recommendations*, Warner Center TMO, Commuter Transportation Services, Inc., 1991).

An important psychological impediment to ridesharing is a reluctance to try the unknown. Ridesharing is unfamiliar to most commuters, most of whom have spent their commuting lives driving alone. The assistance of a Transportation Coordinator (TC) can ease the transition from driving alone for commuters who have decided ridesharing is a viable option, but might be hesitant about making the shift. A TC can assist with individual trip planning, describe what the potential ridesharer can expect, screen potential rideshare partners, and facilitate introductions of the ridesharers. TCs also can ensure that ridesharers are aware of all the incentives and support services available to them, removing the need for commuters to seek out these services themselves.

Several of the *complementary* program elements, such as on-site services and guaranteed ride home (GRH) programs, support decisions to rideshare by reducing commuters' need for a personal automobile during the day. GRH programs have been shown to be highly valued by ridesharing commuters and to have been a supporting factor in their decision to rideshare (*Guaranteed Ride Home Evaluation,* Transit Department, Municipality of Metropolitan Seattle, Seattle, WA, May 1988). Other strategies, such as midday shuttles and employer-sponsored van or shuttle services between worksites (discussed in Section II A.1) also contribute to reducing commuters' need to have a car during the day. Work site design that minimizes the walking distance of transit riders (bus stops close to building entrance, for example) can minimize the time needed to commute by transit, making it a more attractive alternative.

A final, albeit difficult to quantify, way in which *complementary* programs can encourage ridesharing is by creating an environment in which ridesharers are seen as "special" and an asset to the company and the community. Ridesharers help reduce congestion and improve the environment. Promotional activities such as certificates, awards, clubs, and prizes for ridesharers reward these socially appropriate efforts, especially when the promotional activities are highly visible. Seven percent of commuters in a 1989 survey in Brentwood, TN (suburban Nashville) said "recognition" would motivate them to consider ridesharing (*Commuter Survey* conducted by the Brentwood Area TMA, Brentwood, TN, 1989). A corporate culture that supports ridesharing reinforces the impression that ridesharing is a "good citizen" activity.

Complementary programs' roles in encouraging ridesharing can be summarized as follows for each of the elements mentioned earlier:

TDM PROGRAM MARKETING

Information Dissemination - increases commuters' awareness of available TDM strategies, services, and incentives.

Transportation Coordinator - reduces commuters' discomfort with trying a new commute mode; simplifies and personalizes access to information.

Special Promotions - encourages first-time use of alternative mode and rewards continuing ridesharers; generates excitement for TDM programs.

SITE AMENITIES AND DESIGN

"Rideshare Friendly" Work Site Design - eases worksite access for HOV commuters by removing physical barriers to ridesharing; can provide time saving to transit users if walking distance from stops is reduced.

On-Site Services - minimizes commuters' true or perceived need for personal automobile for personal or business-related trips before, after, or during the work day.

SUPPORTING SERVICES

Guaranteed Ride Home - eliminates commuters' fear of being "stranded" without transportation in the event of a personal emergency or the need to work overtime.

Corporate Commitment - reduces ridesharing commuters' fear of ridesharing hindering their "movement up the corporate ladder" by creating a work environment in which ridesharing is promoted as acceptable.

1.3 APPLICATION SETTING

TRAVEL MARKETS

As with TDM strategies, the primary application of *complementary* programs is to the home-to-work (or home-to-school) commuting market, particularly for those programs implemented at employment sites (or universities). Some *complementary* program elements, such as Guaranteed Ride Home and corporate "culture", have little relevance outside of the work site. But other elements, such as site design and general information dissemination, can be targeted to several travel markets.

For example, TDM programs in residential developments can include site design features that encourage pedestrian travel within the development, and on-site services, such as convenience shopping, that allow residents to perform errands without driving. Program marketing at other non-work sites can also encourage use of alternative modes, primarily transit, for non-work trips to these developments. For example, transit use for trips to shopping centers could be promoted by distributing transit schedules at the center, offering discounts from merchants to transit riders, and designing safe, convenient transit access at the center. Information programs also can promote ridesharing for travel to special recreational events such as concerts or sporting events where localized congestion before or after the event would likely occur.

TRAFFIC CONDITIONS

Although traffic congestion or site access problems can boost travelers' interest in ridesharing, and therefore their receptivity to marketing and promotion of TDM, traffic conditions do not have to be problematic for travelers to consider an HOV mode. For example, recent employee surveys have shown a growing willingness of commuters to consider ridesharing for environmental reasons, such as reducing air pollution or the consumption of fossil fuel. Travelers also have other motivations for switching from driving alone, such as the health benefit of bicycling or the reward of a discount on purchases at shopping centers. Ridesharing programs are increasingly focusing marketing campaigns on these themes.

1.4 EXAMPLES

Substantial trip reduction rarely, if ever, occurs solely from marketing or other *complementary* programs. As mentioned earlier, however, these elements do play an integral supporting role in effective TDM programs. Provided below are two examples of the use of *complementary* programs. The first is an employment-site program in which *complementary* programs were used to support a comprehensive package of TDM strategies. The second is an area-wide program that relied primarily on *complementary* programs alone. These two examples are followed by several other brief examples of *complementary* programs, grouped in the categories mentioned earlier.

In most cases, it is impossible to say what proportion, if any, of the trip reduction was due to *complementary* programs. The programs generally include a package of services and HOV incentives in addition to the *complementary* services. As it is not possible to separate the impacts of each of the strategies, these examples are presented as illustrations of the *complementary* programs that are being used, rather than quantitative results on the trip reduction impacts of *complementary* programs.

1.4.1 Transamerica Life Companies (Los Angeles, CA)

Transamerica Life Companies is an insurance company with 3,000 employees in an office near downtown Los Angeles. In 1979, the company established a vanpool program to accommodate a parking shortage and to reduce trips as a community benefit. The program was expanded in 1988 and 1990 to comply with local trip reduction ordinances. In addition to vanpooling, the program now includes parking fees (carpools receive a discount) and a transit subsidy of $15 per month. To support these tangible strategies, TransAmerica offers several *complementary* services:

- **On-site information center** that provides access to program information and ridematching assistance;

- **Guaranteed ride home**, using taxi vouchers, for ridesharers (midday trips paid by TDM program, overtime trips paid by individual departments);

- **Emergency use of company cars** (if available) for ridesharing or GRH; and

- **Secure bike racks and use of on-site health club** showers and lockers for bicycle users and pedestrians.

The site is served by more than 50 bus routes, many of which operate every 10 to 15 minutes during rush hour. TransAmerica simplifies access to transit passes by giving its subsidy to employees in the form of coupons that are redeemable at the RTD transit sales outlet in the building lobby. Employees at the Center also have access to many other services on-site: cafeteria, coffee shop, bank, convenience shopping, health club, dry cleaners, and dental offices. Although TDM staff could not say whether on-site services had increased ridesharing use, they did say the services are well-utilized and that transit users particularly have mentioned the convenience of on-site pass sales.

The TDM staff promote commute alternatives through new employee orientation, a monthly company newspaper, direct mail, and commuter bulletin boards. Employees also may advertise carpool and vanpool openings in the bi-weekly "Oxy Club", an internal employee newsletter.

Shown in Table 1-1 below are mode shares for Transamerica for 1990 and 1991 and for the average downtown LA employer in 1990.

TABLE 1-1
Commute Mode Split
Transamerica Life Companies and Downtown Los Angeles Average

	Commute Mode				
	SOV	Carpool	Vanpool	Transit	Other
Transamerica 1991	45%	21%	19%	14%	1%
Transamerica 1990	49%	20%	18%	11%	2%
DT LA Ave. 1990	61%	18%	2%	17%	2%

As the table shows, this comprehensive package of incentives and support has been very successful. TransAmerica's SOV mode share in 1990 was 49 percent, well below the 61 percent SOV share for the average downtown Los Angeles employer and had fallen further in 1991 to 45 percent. The company's vehicle trip generation rate of 55.5 trips per 100 employees was also below the average rate (69.3 trips per 100 employees) for all downtown employers. On the basis of TransAmerica's 1991 population, this represents a vehicle trip reduction of 377 trips, or 19.9 percent compared to the average. Analysis of Transamerica's success with TDM would indicate that its tangible incentives and disincentives are what have produced its notable trip reduction, but its broad support services have obviously maximized employees' awareness of and intent in using these alternatives.

1.4.2 Contra Costa Centre (Contra Costa County, CA)

The Contra Costa Centre Association, a group of property owners in Contra Costa Centre (San Francisco Bay area), established a TDM program in 1987 in response to a trip reduction ordinance. With the exception of a slightly constrained parking supply and a small vanpool subsidy begun in 1990, the TDM program has been based essentially on *complementary* program elements.

The Centre was designed to encourage alternative mode use. The site is mixed use, with office, hotel, and residential uses, and 34 percent of the land within a quarter mile of the BART station is zoned for housing to encourage a "jobs-housing balance". There are a few restaurant and retail services. Free parking is not abundant. Bike racks and showers are incorporated into most buildings.

The TDM program was started without a designated transportation coordinator. Initial promotional efforts were limited to flyers and posters, an employee newsletter, and a commute fair. The program was carried out primarily by the property owners, with cooperation from building managers and employers. In 1988, a computer ridematching link was established to the Bay Area RIDES data base (regional rideshare match system) and a part-time coordinator was hired. Transportation information centers were established in each building and building coordinators were designated and trained. Promotional events were held at individual buildings. In 1989, the Association received a grant to purchase commuter vans ($87,000 to cover 70 percent of five vans). Transit passes were offered through the Association, but not at a discount. In 1991, transit pass sales were discontinued.

Table 1-2 shows mode share trends for Contra Costa Centre from 1987 to 1990. Except for 1990, solo shares generally have not declined. And, according to the current Coordinator, the decline in solo shares in 1990 (and the boost in BART share) is due to the recent arrival of a new, large tenant relocating from San Francisco. A RIDES study showed that BART users tend to live over 20 miles away from the park.

TABLE 1-2
Commute Mode Split
Contra Costa Centre

	Commute Mode				
Year	**SOV**	**Carpool**	**Vanpool**	**Transit**	**Other**
1987	81%	10%	0%	6%	3%
1988	82%	13%	0%	4%	1%
1989	83%	10%	0%	3%	4%
1990	77%	10%	0%	9%	4%

Among suburban San Francisco TDM programs, the Centre's trip reduction performance has been about average, slightly better than some and slightly worse than others. Comparison to an office park without a TDM program is similarly inconclusive. A survey conducted in 1988 in Walnut Creek, CA found a 90 percent solo share before a TDM program was developed. The two office parks are similar, but Centre employees have longer commutes than do Walnut Creek employees, making them better ridesharing candidates.

Overall, it is difficult to credit the Centre's program with much reduction in solo shares, either from the pre-TDM condition or compared to non-TDM areas despite the fact that the Centre implemented a very extensive *complementary* program, including site design features and amenities, marketing, transportation coordinator, and transit pass sales. **This suggests that *complementary* programs alone, even when comprehensive, are insufficient in influencing commuters to choose alternatives over driving alone.**

1.4.3 Other Examples: TDM Program Marketing

Chevron (Concord, California) - In 1983, Chevron implemented a vanpool program with company-owned vans and a free shuttle bus to BART. The company supports its program with an on-site information and transit pass sales office, bicycle promotions and facilities, and shuttle buses between Concord and other Bay Area Chevron sites. Between 1987 and 1990, Chevron's SOV rate fell from 86 percent to 82 percent, and its vanpool share increased from 1 percent to 5 percent. The which might have increased employees' awareness of TDM options. Results of the annual surveys support this possibility. Employees citing "Don't know with whom to rideshare" as a reason to drive alone decreased from 18.3 percent of responses to 13.0 percent between 1986 and 1989.

Nuclear Regulatory Commission (Montgomery County, Maryland) - NRC began its TDM promotion in 1988 as it was consolidating several offices. To ease employees' transition to the new site and encourage use of ridesharing, NRC created a video "walk through" of the new building that described all the transportation and *complementary* services available to employees. The Commission continues to market TDM with a staffed, prominently-located, on-site information center as well as a self-service interactive computer information system, regular features in the monthly newsletter, and new employee information packets.

Concord Commute Store (Concord, California) - In May 1990, the City of Concord opened the Concord Commute Store, a commuter information center open to the public in downtown Concord. The City had offered commute information before, but from a less prominent location in the City's Finance Department. The new location was far more visible and accessible. The Store's services include rideshare matching, transit fare sales, transit trip planning, bicycle maps, and road construction updates. Store staff conduct commuter promotions at major employment sites, and actively market services to residents through local newspapers, radio, television, and a City-published newsletter. From June 1990 to June 1991, the Store handled over 2,000 requests, an increase of 150 percent over the previous year before the move. The Store's transit pass sales also increased dramatically after the move, by 238 percent, from $18,071 to $61,137.

Warner Center TMO (Woodland Hills, California) - The Warner Center Transportation Management Organization (TMO), which serves a suburban mixed-use center 20 miles west of downtown Los Angeles, actively promotes bicycle commuting. The Warner Center Bicycle Club offers a bike newsletter, special biking events and prizes, a "Bike Buddy" program that matches first-time riders with experienced cycling partners, seminars on safety and maintenance, and discounts at area bicycle shops. The TMO also coordinates location of showers and lockers within the park and advocates improvements in regional bike lanes. The club has over 200 members.

Allergan (Irvine, California) - Allergan is a 1,300-employee manufacturing and sales firm. Its TDM program includes subsidized vanpools and transit passes, a ridesharing bonus holiday, and many *complementary* services. As a special promotion, the company holds quarterly drawings for ridesharers for trips (San Francisco, San Diego, and Las Vegas, for example). Drawings also are held for free tanks of gas and free lunches in the cafeteria. Eligible ridesharers are signed up automatically.

Other Program Marketing - The institution of trip reduction regulations on employers has sparked numerous creative marketing and promotion efforts designed to increase enthusiasm and interest in TDM and to make TDM "fun". For example, employers have included the following promotions in their TDM programs:

- Free walking shoes for pedestrian commuters;
- Free, on-site vehicle fueling and detailing for the "Vanpool of the Week";
- Car washing by the CEO of the company for the "Carpool of the Quarter," (Promotion held at lunchtime to allow employees to watch);
- "Carpooler of the month" is allowed to move to the head of the company cafeteria line;
- A car was given as a prize to the "Carpooler of the Year" (donated by the car manufacturer);
- Ridesharers are given free coffee and donuts in the company cafeteria; and
- The ETC distributes chocolates to ridesharers during the day.

1.4.4 Other Examples: Site Amenities and Design

Allergan (Irvine, California) - Allergan's Irvine office is located in a large campus-style development in a suburban office park. The site is not within walking distance of off-site retail services, but has many personal service establishments on site. They include: a cafeteria, exercise facilities, credit union, ATMs, health office, and a company store (ticket sales, photo developing, postal center, and convenience shopping).

Pentagon (Crystal City, Virginia) - The 26,000 employees of the Pentagon, the largest office building in the country, have access to three cafeterias and a full range of shopping on a retail concourse within the building. Stores include a department store, travel agent, shoe repair, post office, drugstore, and other small shops. The Pentagon also encourages use of transit through its site design. The building is located over a MetroRail subway station and has direct access from the station. The station also is a major transfer point for transfers from rail to bus.

San Diego Trust & Savings Bank (San Diego, California) - This downtown San Diego bank is within easy walking distance of shopping, restaurants, and personal service establishments. One close-by service important to transit users is the Transportation Center operated by San Diego Transit located across the street from the bank. The

Center provides transit information and sells fare media. Some services, such as a subsidized employee cafeteria, fitness center with showers and clothes lockers, and ATMs, are available on-site.

The Rideshare Company (Hartford, Connecticut) - The Rideshare Company, a regional ridesharing program, and the City of Hartford created vanpool staging (pick-up and drop-off) zones on city streets. The zones were prominently marked as distinct from commercial delivery zones to minimize conflicts with delivery vehicles and automobiles.

Xerox (Palo Alto, California) - Twenty percent of the 500 employees at Xerox' Palo Alto office bicycle to work. Bicycle facilities on-site and a corporate commitment to bicycling have made this possible. Secure bike lockers are provided in a covered area in front of the company security office and bicyclists have free use of personal lockers and showers. Xerox also includes bike displays from bicycle manufacturers and local shops at its periodic bike fares. Employees also have flex-time. The City of Palo Alto further encourages bicycling by providing a 40 mile network of bike lanes and paths throughout the area and distributing maps of city and county bike routes. The City estimates that 14 percent of area commuters ride a bicycle to work.

1.4.5 Other Examples: Support Services

Bechtel (Gaithersburg, Maryland) - Bechtel operates a fleet of company-owned vanpools and supports their use with a guaranteed ride home program. Vanpoolers have several options if they need alternate transportation due to a midday emergency or due to working overtime. Bechtel maintains a fleet of company vehicles that can be used in emergencies. The company also operates an AVIS rental car counter on site, so that employees can rent cars if necessary (cars can be charged to appropriate projects if employees work overtime).

Warner Center TMO (Woodland Hills, California) - The TMO administers a Guaranteed Ride Home (GRH) program available to over 7,500 ridesharers at nearly 30 companies. The service provides free transportation for midday emergencies. Taxis are used for trips of under 20 miles and rental cars (free pick-up by rental car company) are used for trips over 20 miles. In a 1990 survey, 37 percent of the over 600 employees who began ridesharing during the past year said the GRH program was a "very important" factor in their decision not to drive alone.

Seattle Metro, Easy Ride (King County, Washington) - Seattle Metro implemented a GRH demonstration program as part of a TDM project in suburban areas in King County. To be eligible, commuters were required to rideshare three or more days per week and register with Metro for the GRH program. Transportation was provided through a taxi company and commuters were reimbursed through a voucher system.

Commuters could use up to 40 miles of taxi travel, about four average trips. Participants indicated the program was important in their decision to rideshare. "Overall, 69 percent of the survey respondents, including commuters who shifted from an SOV mode to an HOV mode when they joined the program, indicated that the Guaranteed Ride Home program was somewhat or very important in their decision to continue to take the bus, carpool, or vanpool to work. Twenty-two percent rated it very important." (*"Guaranteed Ride Home: An Insurance Program for HOV Users"*, Eileen Kadesh and Laurie Elder, Municipality of Metropolitan Seattle, Seattle, WA, 1991. Presented at TRB.)

Lawrence Livermore Laboratories (Livermore, California) - Lawrence Livermore is a 7,200-employee company located near a BART station. In the early 1980s, the company developed an aggressive TDM program that included express buses, a shuttle to BART, vanpools, company bicycles and support. The program was promoted by an on-site ETC. Over a five-year period, the company achieved a decrease in SOV commuting from 85 percent to 36 percent. More recently, however, SOV commuting has climbed back to 51 percent, due in part to a reduction in program staffing and reduced level of promotion. (*"Guaranteed Ride Home: An Insurance Program for HOV Users"*, Eileen Kadesh and Laurie Elder, Municipality of Metropolitan Seattle, Seattle, WA, 1991. Presented at TRB.)

San Diego Trust & Savings Bank (San Diego, California) - Management support for the bank's commute program has been quite strong. Although the bank is now required by an ordinance to promote TDM, it began its program voluntarily as a service to employees. Management has been sensitive to employees' need for flexibility. Employees are unofficially allowed flexibility in work hours to arrange ridesharing or meet transit schedules. Another unofficial company policy is that overtime is not expected and meetings are not scheduled for late in the day. Management also has been deeply involved in local transportation management projects. SDTSB was a founding member of the Downtown San Diego TMA, and has served on its Board of Directors for two years.

1.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

The impact of *complementary* programs on mode choice is difficult to estimate. Much of the evidence of TDM effectiveness comes from case studies of "stellar" TDM programs, programs that have shown impressive trip reduction. Stellar results rarely have been achieved without implementation of a significant package of tangible HOV incentives. It is difficult to isolate the impact of *complementary* programs on commute mode choice because the impacts of these far more effective strategies overshadow any incremental impacts of marketing programs and support services. This said, however, several research projects have examined aspects of *complementary* programs' impacts. These results are discussed below under the three program categories described earlier.

TDM PROGRAM MARKETING

Information Dissemination

Recent results on the impact of program marketing on mode choice come from two projects, *"Easy Ride"* and the *"HOV/TSM Evaluation Study"*, conducted by Seattle Metro between 1987 and 1989. (*An Assessment of Travel Demand Approaches at Suburban Activity Centers,* K.T. Analytics, Inc., Frederick, MD, 1989. Prepared for U.S. DOT, Urban Mass Transportation Administration; *An Evaluation of Easy Ride: A Pilot Transportation Management Project,* Transportation Management Services, Pasadena, CA, January 1990. Prepared for City of Bellevue, WA, Planning Department.) Easy Ride, a joint demonstration project of Metro and the City of Bellevue, was designed to test the trip reduction impacts of a marketing program targeted directly to employees at suburban areas. The demonstration included a limited vanpool subsidy, but the major tactic was information distribution and the use of Transportation Coordinators to promote the program and provide personalized trip planning. Metro produced marketing materials, distributed them through "take one" displays, and held promotions at employment sites. A Guaranteed Ride Home program also was implemented.

Three commuter surveys conducted over the two-year project period showed no significant increase in HOV use between 1987 and 1989. Coordinators had registered about 4.7 percent of the combined employee population of the two areas as new ridesharers, but an equal percentage of employees shifted from HOV to drive alone. A few individual sites achieved notable trip reduction; the drive alone rate at Bellevue City Hall fell from 79 percent to 48 percent, for example, but these were clearly the result of significant financial incentives.

Also in 1987, Metro began the HOV-TSM Evaluation Study, in which it monitored the performance of TDM programs in four suburban areas. As with Easy Ride, its primary purpose was to evaluate the effectiveness of transportation programs and incentives, but it also measured employee awareness of the programs and incentives. HOV/TSM commuter surveys showed results similar to those of Easy Ride. Between 1988 and 1989, 5.5 percent of employees at the target sites switched from SOV to HOV, but as an equal number of HOV employees began driving alone, there was no net increase in ridesharing.

During each of the two years there was a slight difference between the mode shift at the HOV/TSM target sites and that at eight control sites, however. At the control sites, a smaller percentage of employees (4.7 percent) switched to HOV and a larger percentage (6.0 percent) switched to SOV, to give a small net increase in drive alone. This suggests that, although the project did not increase ridesharing, it might have had a very small, perhaps 1-2 percent, *impact on maintaining ridesharing at the target sites, probably by rematching ridesharers whose ridesharing arrangements changed.*

The HOV/TSM project also assessed changes in employees' awareness of the program and incentives. Awareness did increase over the course of the study, most markedly during the first year with somewhat less increase during the second. Awareness varied between sites. Employees in the Bellevue CBD had the highest awareness of the program, but much of this was attributed to the TDM marketing that had been conducted by Metro and the Bellevue TMA for several years. Awareness was highest for the on-site promotions and lower for specific services and incentives. Increases in awareness were accompanied by either a decrease in the proportion of SOV commuters or no change.

Staff of several TDM programs cited the need for ongoing promotional efforts to counter the incidence of employee and resident turnover, and to reach commuters whose commute patterns had changed (*HOV/TSM Evaluation Study, Final Report*, Transit Department, Municipality of Metropolitan Seattle, July 1990). For example, in the mid 1980s, when a San Francisco company surveyed its employees, it found that 24 percent of first-year employees (who received information on ridesharing as part of employee orientation) began ridesharing, while only 20 percent of employees who had worked one to ten years and only 11 percent of the employees who had worked at the company more than 10 years, began ridesharing (*Conversations with TDM Staff* of the Rock Spring Park Commuter Service Center, Bethesda, MD; Germantown Share-A-Ride, Germantown, MD; and State Farm, Costa Mesa, CA). Although data were not available to determine whether there were significant differences between the three employee groups (commute distance, for example), *these results suggest that keeping employees aware of TDM options and making information available at the time of a change in commute circumstance can be a factor in encouraging ridesharing.*

Transportation Coordinator (TC)

The Seattle HOV/TSM project also explored the role of the Transportation Coordinator in mode choice. Although the overall impact of the HOV/TSM program on mode choice was slight, the presence of the Transportation Coordinator seemed to make a slight difference in employees' likelihood to shift to ridesharing. In the target area, where the TCs' effort was greatest, 48 percent of the employees who began ridesharing during the two years cited activities of the TC as ***contributing*** to their shift. At the control sites, only 39 percent of the ridesharing employees mentioned these activities (conducted by Metro as part of its base level of TDM promotion) as a factor. The TCs in the Easy Ride demonstration also felt that they were most effective in the buildings in which they were stationed because they became a familiar and easily accessible information source for employees.

In another study, conducted in the early 1980s, the New York State DOT studied the effect of an on-site TC on the commute mode choice of state workers. Controlling for the high baseline rideshare formation due to the oil crisis of that time, the DOT found that ridesharing increased an average of 10 percent at the agencies with a TC, but an average of only 3.5 percent in the agencies without a coordinator. The study thus estimated a 6.5 percent increase in ridesharing "directly attributable to carpool coordinators." (*Traffic Mitigation and Demand Management, Summary of National Experience and Potential Applications in New York*, Richard Oram, July 1987. Prepared for C.B.D. Access Group and Port Authority of New York and New Jersey.)

A 1982 study examined the impacts on mode choice of "personalized" ridematching and information programs. The study used data from Silver Spring (MD) Share-A-Ride, an area-wide rideshare program that used a highly personalized ridematching approach and substantial follow-up of all applicants. The study did not measure trip reduction as a result of the program, but the importance of personalized assistance and follow-up was indicated by the fact that 33 percent of applicants who received a match list had not contacted any commuters listed on the match list prior to their first follow-up call from Share-A-Ride staff. Following the call, 73 percent of these applicants entered ridesharing arrangements. (*Traffic Mitigation Reference Guide, A Review of Options Available to the Public and Private Sectors*, MTC, Oakland, CA, December, 1984.

Finally, a 1988 study examined the impacts of several factors, among them the presence of a transportation coordinator, on commute mode shares at 46 suburban employment center sites. It found that sites with a TC had a 3.4 percent reduction in drive alone commuting compared to sites without a coordinator. (*"Measuring the Effectiveness of Personalized Ridesharing Assistance"*, William R. Hershey and Alexander J. Hekimian, 1983. Presented at TRB.)

Special Promotions

Information regarding the impacts on mode choice of special promotions, such as drawings for ridesharers or commute fares, is largely anecdotal. Promotions, especially those held on a regular basis, such as quarterly prize drawings, seem to generate initial awareness of the TDM program and are useful in maintaining awareness, especially important in companies with high employee turnover. The Rock Spring Commuter Service Center, a commuter information service sponsored by a developer in a large office park in suburban Washington, D.C., reported that nearly half of its ridematching applications (48 percent) came from information day promotions held at employment sites. The next highest sources of applications were new employee orientation, which produced 16 percent of the applications, and co-worker referrals, which produced 7 percent ("*Rock Spring Commuter Service Center Annual Report,*" September 1992, Bethesda, Maryland).

Transportation Coordinators of several employer and area-wide programs confirmed that special promotions designed to generate ridesharing applications do not necessarily generate new ridesharers, as some applicants sign up only for the prize. For example, in the report mentioned above, although promotions produced 48 percent of ridematching applications, they produced only 41 percent of the new carpool and transit arrangements, while co-worker referrals, which accounted for only 7 percent of applications, accounted for 14 percent of commuters matched into carpool and transit arrangements. Promotions used as a reward for current ridesharers perhaps are more successful, but data are not available to suggest an impact. The Westchester/LAX TMA in Los Angeles has said that some employers have joined the TMA to take part in the TMA's ridesharing fares and to take advantage of cross-company ridesharing opportunities.

Overall Impact: **The research discussed above suggests that program marketing, although an important element of a TDM program, largely is ineffective alone. Shifts to ridesharing as a result of information programs can be expected to be only 0-3 percent. The presence of an on-site Transportation Coordinator seems to make TDM programs slightly more effective, but again, only a marginal impact is likely.**

Site Design and Amenities

As with special promotions, little definitive research has been done to estimate the impact of work site design or amenities on commute mode choice. A few employee surveys have indicated that access to on-site services is a factor in employees' mode choice for many employees. The surveys cannot conclude that employees will rideshare if services are available, but employees clearly are less willing to rideshare when services are not available.

One study, a 1988 review of suburban employment centers (SECs) nationally, found that ridesharing was more prevalent at large, relatively dense, mixed-use developments and sub-cities and in settings with substantial retail components. Approximately 20 percent of employees in these development types used ridesharing, compared to 14 percent to 16 percent at other types. The researchers concluded that "SECs that are denser and have restaurants, shops, banks, and other consumer services on-site can be expected to enjoy relatively high rates of vehicle pooling, all other things equal. ... The availability of commercial activities appears to induce a number of employees to carpool and vanpool to work." (*Results of CTS Analysis of Rideshare Fares,* 1988.)

<u>Overall Impact</u>: **Work site design and the presence of on-site services may contribute incrementally to employees' decision to rideshare, by making ridesharing a more convenient mode than before, but conclusive data are not available. Provision of special facilities for bicycling and walking seems to be more effective in increasing use of those modes, but the absolute numbers of commuters typically remain small even when percentage increases are large.**

Support Services

Guaranteed Ride Home Programs

A Guaranteed Ride Home program is the *complementary* program element that will most likely have an impact on commute mode. Numerous surveys have confirmed that a GRH program is an important factor in commuters' decision to start ridesharing and to stay in a rideshare mode. In 1989, the Warner Center TMO conducted a survey of employees in Warner Center, a suburban Los Angeles employment center, in which employees were asked what incentives would encourage them to rideshare. Thirty-two percent answered Guaranteed Ride Home. One year later, after implementing the GRH program, the TMO conducted a second survey, asking employees who had begun to rideshare during the past year, what incentives had influenced their commute mode decision. Of the 1,676 new ridesharers, 36 percent indicated that GRH was *one such factor.* (*America's Suburban Centers, A Study of the Land Use-Transportation Link*, Dr. Robert Cervero, University of California, Berkeley, Berkeley, CA, January 1988. Prepared for UMTA, Office of Policy and Budget.)

Seattle Metro also found evidence that the GRH program it implemented in 1988 had been a factor in some employees' commute mode choice. At the end of a six-month demonstration period, participants were surveyed to determine GRH's impact on their mode choice. Twelve of the 142 participants (8.5 percent) said they had changed from driving alone to an HOV mode after they heard of the GRH program. All who responded to the survey found GRH to have been important in their decision to shift. (*Results of CTS Analysis of Rideshare Fairs*, 1988.)

The survey also showed that participants made fewer SOV trips after the GRH program was implemented than before it began. Before the program started, the 142 participants (130 ridesharers and 12 SOVs) made 349 two-way trips per week, of which 52 (15 percent) were SOV trips. After six months, the number of SOV trips had fallen to 15 (4 percent). The difference of 37 trips, a 12 percent increase, was attributed solely to the 12 commuters who had changed to an HOV mode after they heard of the GRH program.

The program was expanded following the six-month demonstration period and SOV commuters were targeted with information. At the end of one year, 260 commuters, of which 25 percent were former SOV commuters, had enrolled in the program. Again, GRH was cited as a factor in their decision to begin or continue ridesharing. GRH probably was not, however, the most compelling reason why these employees switched to ridesharing. Focus groups conducted by Metro elicited comments from some solo commuters that they "needed more incentives than just GRH to get them out of their cars."

The Metro data suggest that GRH may have more impact on keeping current ridesharers from switching to SOVs. Of commuters who were ridesharing before the GRH demonstration, 22 percent indicated the program was very important in their decision to continue to rideshare and 46 percent rated it somewhat important. Metro concluded that "GRH played a role in helping to maintain the level of HOV usage for those who were already using an HOV mode most of the time," but that "the GRH incentive on its own does not appear to be as useful for motivating people to enter ridesharing as to continue it."

Corporate Commitment

The impact of strong corporate commitment on commute mode is particularly difficult to estimate. Companies with strong support for TDM generally provide many tangible HOV incentives which have a substantial impact on commute behavior under almost any work environment. Again, impact can only be suggested.

In Seattle Metro's HOV/TSM project, the TCs rated each employment site with which they had contact by the level of cooperation they received. Analysis of these ratings showed that the sites at which they received the most cooperation were also the sites with the highest HOV mode split. According to the final report of the HOV/TSM Evaluation Study, "mode split was significantly different between high effort/cooperation sites and medium or low effort/cooperation sites." In 1989, 28.7 percent of the employees at high effort/cooperation commuted by an HOV mode compared to 13.1 percent at medium or low effort/cooperation sites. The report went on to say, however, that "that condition existed before the TCs began working with the employment sites." In 1987, 28,8 percent of employees at the high cooperation sites used an HOV mode compared to 19.2 percent at the low cooperation sites. (*Guaranteed Ride Home Evaluation,* Transit Department, Municipality of Metropolitan Seattle, Seattle, WA, May 1988.)

There have been several cases in which SOV mode crept up after a significant decline when commitment to the program declined. At Lawrence Livermore Labs (mentioned earlier), for example, emphasis on marketing the TDM program lessened after several years. The SOV rate, which had fallen from 85 percent to 36 percent, rose to 51 percent when commitment to the program declined. 3M, in St. Paul, also experienced an increase in SOV mode share over time. Between 1972 and 1980, the company's SOV mode share consistently declined from 92 percent to 80 percent, primarily through an aggressive vanpool program. Participation in the vanpool program fell off after 1980 and SOV use began to creep up, however. Company representatives indicated that top management support for the program began to wane. (*HOV/TSM Evaluation Study, Final Report*, Transit Department, Municipality of Metropolitan Seattle, July 1990.)

Overall Impact: **The importance of GRH as a supporting element in trip reduction seems to be clear, although as with other *complementary* programs, its impact alone likely is small. It is a "very important" incentive for a small percentage of commuters, and perhaps strongly contributes to the mode choice decision of 2-5 percent of commuters who shift to ridesharing. The influence of a strong corporate commitment on decisions to rideshare, although suggested by ETCs at many companies, is so overshadowed by the impacts of the comprehensive TDM incentive packages implemented by these companies that it is impossible to assign a numerical impact.**

1.6 COST EFFECTIVENESS

Complementary programs can include cost items in each of the three groupings. Costs for program marketing are the most common, and are incurred, at some level, by all TDM programs. The primary marketing expense often is for staff, typically a full- or part-time ETC. Some of the ETC's time might be devoted to non-promotion tasks, such as preparation of trip reduction plans for regulatory compliance and program reporting, but in most cases, the full cost of staff salaries is attributable to program promotion and administration of subsidy programs. Other marketing costs include expenses for preparation of marketing materials, program advertising, and special promotions such as prizes or fairs. Table 1-3 shows typical costs for marketing and administration of TDM programs and for GRH programs.

Costs for marketing vary greatly depending on the situation. Costs for employer programs range from $10,000 on up. The lower ranges assume promotion by a part-time ETC and minimal program promotion. An average cost to market to 1,000 employees is about $45,000 (one full-time ETC and direct promotion costs). Area-wide programs, which typically have a larger target market, usually hire more than one staff member and have correspondingly higher costs for both staff and promotional materials.

Costs for other *complementary* elements also vary greatly by situation. Site design elements can include capital costs for construction of bicycle, pedestrian, and ridesharing facilities and operating costs for facilities' maintenance. Costs can also be incurred for provision of on-site services. For example, an employer might pay a higher lease cost for space in a building with amenities. Developers' costs could include construction, tenant search, and subsidized rents, although on-site services can produce income for the property owner, if market rents can be charged.

Table 1-3 also shows costs for Guaranteed Ride Home programs under several assumptions. GRH costs vary by the number and trip patterns (average commute distance, percent ridesharing) of commuters covered by the program and the usage rate, which varies by the specific characteristics of the population and program (emergency versus overtime use, for example). The table provides cost ranges for two usage rates, 1 percent of eligible employees and 10 percent of eligible employees, and three eligible commuter populations, 100, 500, and 5,000 commuters. Costs for a program with 100 eligible commuters (1,000 with 10 percent ridesharing, for example), whose average trip length is 15 miles, would range from $30 to $300 for trip costs, plus the cost of planning and administering the program.

If we assume that an employer with 1,000 employees implements a moderate TDM program with marketing and a GRH program, its cost is likely to be on average $26,000 ($23,000 for part-time ETC and marketing and $3,000 for GRH). If the *complementary* program alone increases ridesharing by no more than 3 percent, or 15 trips at this employment site (if all switch to 2-person carpools), the cost per trip removed would be $1,734 per year or $6.88 per trip per day. Marketing and GRH programs generally support the implementation of more tangible program elements, however, and the total TDM program trip reduction probably would be higher. With the same level of marketing effort, the contribution of *complementary* programs to the total cost per trip reduced likely would be smaller.

1.7 IMPLEMENTATION ISSUES

The most important issue to be remembered in implementing *complementary* program elements is that they should be implemented in concert with tangible TDM incentives, rather than alone. As stand-alone programs, they have little impact on mode choice. With this in mind, implementation of *complementary* programs then refers to how these elements can be designed to support tangible incentives most effectively, be most cost-effective, and most easily managed as part of a comprehensive TDM program.

TABLE 1-3

Typical Cost of Complementary Program

Program Marketing[1]	
Employer programs	
- fewer than 1,000 employees	$10,000 - 55,000/year
- over 1,000 employees	$18,000 - 100,000+/year
Area-wide programs	$62,000 - 250,000+/year
Guaranteed Ride Home[2]	
Planning/Administration Cost	$3,000 - 15,000
Estimated Annual Trip Cost (15 mi. trip):	
- 100 eligible commuters	$30 - 300
- 500 eligible commuters	$150 - 1,500
- 5,000 eligible commuters	$1,500 - 15,000

(1) Program marketing includes costs for one staff member (65 percent), marketing materials (15 percent), special promotions (15 percent), other (5 percent). Source: COMSIS 1991 Case Studies of TDM programs.

(2) GRH trip cost ranges assume 1 percent to 10 percent use rate (percent of eligible employees who use GRH program during a year) and 15-mile average trip ($30.00 per trip by taxi or rental car). Source: Guaranteed Ride Home: Taking the Worry Out of Ridesharing, Commuter Transportation Services, Los Angeles, California, 1991.

The effectiveness of program marketing can be increased by the following:

- Information materials should reflect the characteristics and attitudes of the target population (e.g., travelers' interests in environment versus cost saving).
- Promotions should be appropriately scaled to the target population (e.g., mass media advertising for regional information campaigns and desk-to-desk information distribution at employment sites; vanpool information targeted to long-distance commuters and bicycle information to short-distance, etc.).

- Marketing should be highly visible and continuous to reach new employees or residents of the target area, and travelers whose travel needs have changed.

- Information centers (on-site or off-site) should be in easily accessible locations and staffed with trained commute professionals.

Administration of the program should consider the following issues:

- Promotions that include prizes and drawings for ridesharers should be clearly defined as "rewards" for ridesharing, to avoid equity issues with single occupant drivers, who are not permitted to participate.

- Company (or agency) policies regarding TDM use and incentives should be clearly defined and monitored, to ensure compliance with the policies.

- The TDM program should establish goals and progress should be evaluated on a regular basis to ensure the program incentives and *complementary* program elements are effective (and cost-effective relative to other potential strategies and techniques).

- If employers (or other TDM implementors) are implementing an untested TDM strategy, they should consider implementing a demonstration or pilot program, to evaluate its effectiveness and estimate the costs on a small scale.

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B.2 PREFERENTIAL HOV TREATMENTS

2.1 DESCRIPTION OF STRATEGY

Preferential HOV facilities can be an effective way to encourage travelers to use higher-occupancy modes of travel, such as transit, carpools or vanpools. By dedicating certain portions of a highway or supporting transportation facilities to exclusive or priority use by high-occupancy vehicles, users of these modes will realize a travel time advantage. This advantage, which presents itself in terms of reduced travel time and greater predictability of travel time, in turn serves as an important incentive to encourage use of HOVs.

HOV facilities can occur in numerous forms, but the general idea is to design or operate the transportation facility in such a manner that HOV users are given priority treatment. The following is a list and brief description of the generic types of HOV priority facilities:

- *Separate Roadways for Exclusive HOV Use:* A roadway or lane which is built on a separate right-of-way and designated for the full-time exclusive use of high occupancy vehicles;

- *Barrier-Separated HOV Facilities:* A roadway or lane which is built within the right of way of a general use facility, but which is physically separated by barriers from mixed traffic and dedicated for HOV use only;

- *Non-Separated HOV Facilities:* designation of a lane or lanes for exclusive use of high-occupancy vehicles without physical separation, but only through the use of signing, striping, pavement markers, or buffer strips;

- *Queue Bypass Facilities:* designation of an entrance ramp, intersection, or lane(s) at a ramp/intersection for priority access or bypass of mixed traffic queues.

These are the typical ways in which HOV facilities are physically presented. Another dimension is in how they are operated, where the options are:

- *Full-Time Dedicated:* The facility is always used for HOV travel only;

- *Reversible/Directional Facilities:* The facility operation is changed to accommodate HOV travel in the direction of the dominant (peak) traffic flow, generally in the morning and evening rush hours;

- *Contraflow Lanes:* The HOV lane(s) are taken from those facilities which are flowing in the opposite (counter) direction, to take advantage of morning and evening peak traffic flow imbalances.

Still another dimension that distinguishes HOV applications relates to the way in which they are introduced, with two important differences:

- *Add a Lane:* The HOV lane(s) are introduced as entirely new capacity, thereby preserving the existing highway capacity for mixed-use traffic.

- *Take a Lane:* The HOV lane(s) are introduced by reallocating the facilities which are already present, thereby taking capacity away from existing traffic.

2.2 NATURE OF EFFECTIVENESS

If the objective is to have travelers make greater use of travel modes that carry more than one person -- transit, carpools, vanpools -- it must be recognized that there are certain inherent disadvantages to using those modes that must first be overcome. Viewed from a door-to-door perspective, use of HOV modes requires additional travel time and difficulty. The user must make special efforts to reach or connect with the mode, and as a result will generally experience a longer trip than if he or she drove alone directly from home to their destination.

HOV preferential facilities attempt to rebalance this equation, and in effect "give back" some of the HOV user's time investment so that their resulting travel time is more comparable to driving alone. Typical HOV users may have to walk or drive five to ten minutes out of their way to connect with a vanpool or transit line, and some may realize overall travel times that are as much as twice as long as driving alone, even though that driving is taking place on an increasingly congested highway system. Well-designed and properly-situated HOV facilities can give back all or a good portion of this investment by making the HOV trip shorter, faster and more convenient. Users of Washington, DC's Shirley Highway HOV lane, for example, were found to have savings averaging 10 to 15 minutes per trip.

Perhaps as important as the actual time savings is the perception of savings and the degree to which the user can "rely" on a particular travel time. Many HOV users are attracted to the fact that the facility is dedicated to their exclusive use. It is a relief to be traveling along in a free-flowing HOV lane while fellow motorists are inching along at bumper to bumper speeds in the adjacent lane, or queued in long lines at entrance ramps. For example, users of Minneapolis's interim HOV lane on I-394 saved an average of only about eight minutes per trip, though they perceived savings of between 10 and 15 minutes. For the would-be HOV user traveling in the highly congested mixed traffic lane, being able to observe fellow commuters whizzing by in the express lane produces an undeniable pressure to try to take advantage of this benefit. So, in the final analysis, an HOV facility may not have to completely make up for the entire time differential with the SOV -- the perception and freedom from congestion alone may be enough to produce the desired change in behavior.

2.3 APPLICATION SETTING

Priority HOV facilities seem to work best as a strategy under the following conditions:

TRAVEL MARKETS

The types of travelers who are most likely to use HOV facilities are commuters, whose travel occurs mainly during weekday peak periods. This has to do with congestion (see "Traffic Conditions") and with gaining repetitive familiarity with use of the lane and its time savings. Non-work travelers may not understand the facilities well enough to use them effectively. Hence, the facilities will be most effective in areas where there is a high percentage of work travel in the peak service hours.

TRAFFIC CONDITIONS

HOV facilities work best when there is sufficient traffic congestion to create significant travel delay. The HOV facility will be effective to the extent that it offers visible time savings to HOV users.

LOCATIONAL SETTING

Historically, the most successful HOV applications have been along "radial" corridors into major central cities; this is because of several overlaying factors, including population/employment densities, travel volumes, congestion levels, overall time savings and conditions at the destination area. Relatively little experience has been gained with HOV facilities in suburban/exurban areas, such as along circumferential corridors (i.e., beltways) or suburban arterials. The issue in these suburban applications is largely one of the diffuse trip patterns of suburban travelers. Diffuse trip patterns make it harder to design viable transit service or even to form carpools, and suburban trips may not travel on one facility long enough to capture sufficient time savings to have it change their behavior.

SUPPORTING STRATEGIES

The travel time advantages provided by HOV priority facilities are but one part of a complex equation by which travelers make decisions about which mode to use. It is also extremely important for potential users to have viable "alternatives" to switch to, and relevant incentives to further encourage their use. For example, reasons why the Shirley Highway enjoys such a high level of utilization include:

- Conditions at the primary destination (downtown Washington, DC) discourage driving alone -- parking is either scarce, expensive, or its use conditioned on being in an HOV;

- There is excellent transit service in the corridor that is designed to make maximum utilization of the HOV lane and the regional MetroRail system;

- Employer-based carpool and vanpool programs provide would-be users with solid options to driving in terms of information on pooling partners, vanpool formation assistance, and employer encouragement of utilization;

- Both formal and informal facilities and systems allow for the staging of people into pools and transit along the Shirley Highway; park-ride lots for transit and "instant carpool" formation areas where individuals seeking a ride, and pools requiring additional occupants, link up to meet HOV occupancy requirements.

Occupancy Levels and Enforcement

The challenge in making HOV facilities (particularly exclusive lanes) attractive and effectively utilized is to provide a sufficient time savings to users. The degree of time savings is determined by the relative speed with which traffic moves along in the HOV lanes versus the mixed traffic lanes; the greater the differential, the greater the time savings. Theoretically, this speed differential is maximized by placing restrictions on use of the HOV facility -- typically by setting a minimum occupancy requirement (persons per vehicle). If this requirement is set high (three or four persons minimum per vehicle), the number of vehicles using the lane will be small, speeds will be high, and travelers will be encouraged into higher-occupancy units. However, setting the occupancy restriction too high can be counter-productive. In markets where HOV use is modest, it may be difficult to form a sufficient number of pools to justify the lane, so efficiency objectives may be satisfied more effectively by setting a lower limit, such as two or more. Operationally, the lane can be managed such that over time, as traffic conditions change, the occupancy rules can be modified to secure the best travel time/utilization balance.

Enforcement is the mechanism by which the lane's performance is ensured. Travelers who do not meet the requirements of the lane must be restricted from using it, or the travel time bonus to legitimate users will be eroded. Effective enforcement, either through design or operation, is imperative to preserve the time savings incentive to users, and legitimize its dedication to those who make the extra effort to form an HOV.

2.4 EXAMPLES

There are quite a number of examples of successful installations of HOV priority facilities in the United States. Several are briefly discussed here as case study examples, and the reader is also presented with a reference list for further research on these or other examples.

2.4.1 Houston Transitway System

In the early 1970's, the Houston area was experiencing growth and traffic trends that were creating some of the most congested freeways in the nation. Recognizing the economic and physical impossibility of providing enough highway capacity to serve the demand created by reliance on low-occupancy vehicles, local officials developed a scheme was developed to implement a system of preferential lanes for HOV's on the freeways. Locally, these lanes are referred to as "Transitways", because they were initially made available to buses and authorized vanpools only. Over time, to improve utilization and efficiency, the operating rules have been modified to allow selective use of the lanes by carpools as well.

At the end of 1989, 36.6 miles of Transitways were in operation, involving segments on four different freeways. Their location is illustrated by Figure 2-1. These include: the North (I-45N) Transitway, which opened in 1984; the Katy (I-10) Transitway, also opened in 1984; and the Gulf (I-45) and Northwest (US 290) Transitways, which opened in 1988. As seen in Figure 2-1, all of these facilities are radial to the Houston CBD, and are part of what is ultimately planned to be a 95.5 mile system.

Physically, this system has some segments of two-way highway, but the typical installation is a separate, one-way facility located in the freeway median, approximately 20 feet wide, reversible, and separated from the mixed-use freeway lanes by concrete barriers. In most instances, access to and from the Transitways is provided by grade-separated HOV ramps. As stated, the initial priority lanes (I-45N and I-10) were opened as transit and vanpool facilities only, but subsequently opened to carpools as well to improve utilization. The more recent lanes on I-45 and US 290 were open to carpools of two or more from the start. The travel time savings afforded to HOV users averages 5 to 14 minutes on the older facilities, and two to three minutes on the newer ones. Users, however, *perceive* the travel time savings to be 20 minutes and 10 to 20 minutes, respectively. The impact of these real or perceived savings is demonstrable: transit ridership and carpooling has essentially doubled in the older (I-45N and I-10) corridors.

The impact of these HOV facilities as a transportation management strategy is reflected in Table 2-1.

Figure 2-1
Systemwide Facilities

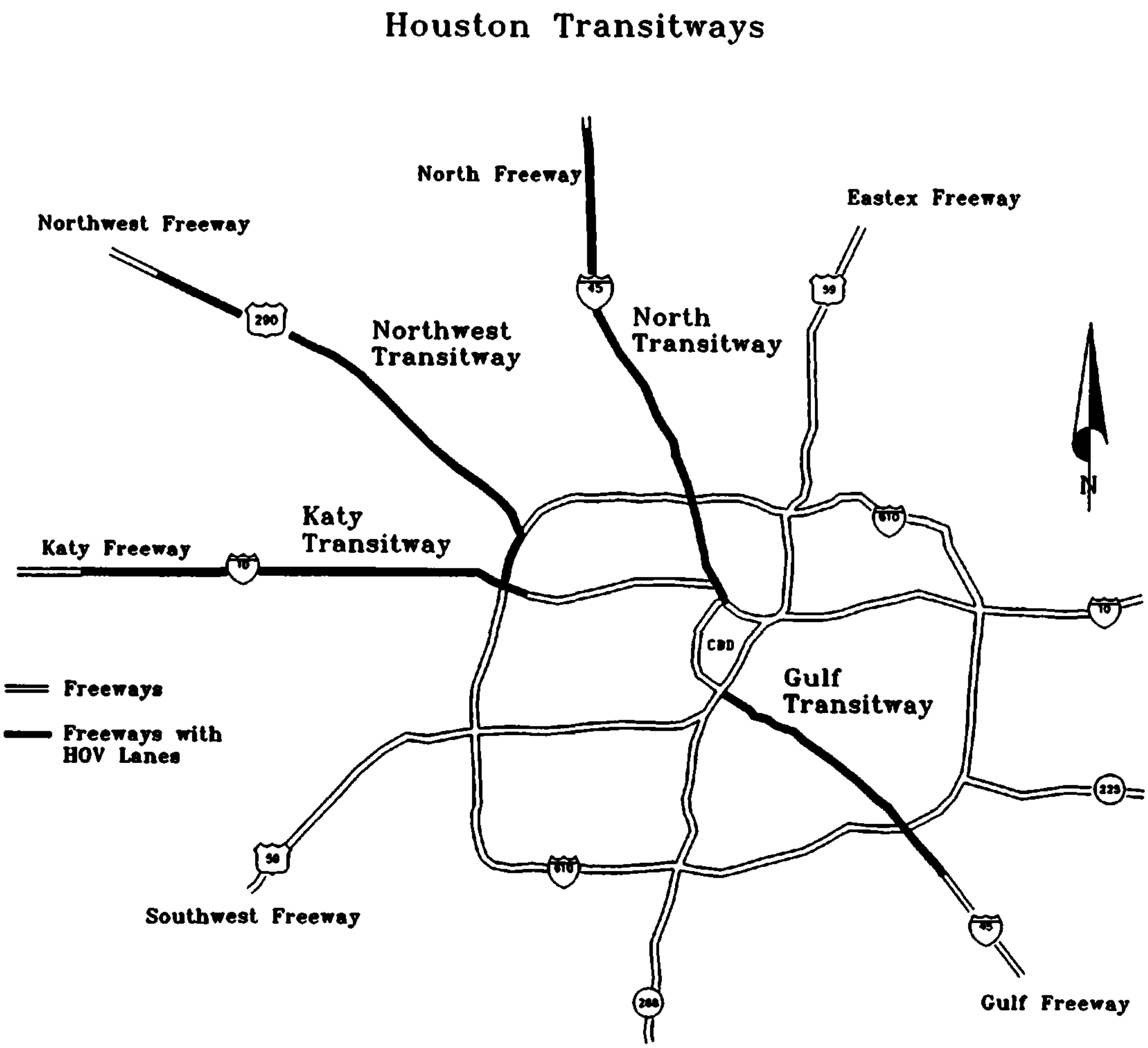


TABLE 2-1

Transit/Carpooling Ridership in HOV Facilities

Facility	Pre-Transitway Vehicle Trip Rate*	Post-Implementation Vehicle Trip Rate*	Percent Decrease
North (I-45N)	78	60	23%
Katy (I-10)	79	68	14%
Northwest (I-45)	88	76	14%
Gulf (US 290)	N/A	N/A	N/A

* Vehicle trips to transport 100 travelers.

As indicated in the above table the carrying efficiency of each of the facilities before and after implementation of the HOV lanes. This is expressed in terms of the number of vehicle trips it would require to transport each 100 travelers in the peak direction during peak hour at the vehicle occupancy levels observed before and after addition of the lane. Installation of the transitway on I-45N produced results that can be interpreted either as a 23 percent reduction in the vehicle trip demand on the freeway as a result of the Transitway, or as a 23 percent improvement in the ability of the freeway to transport people. The Katy and Northwest Transitways reflect 14 percent decreases in vehicle trip demand. These are significant trip reduction measures.

2.4.2 I-394 Interim HOV Lane

Interstate 394 is a major link in the Minneapolis transportation system, connecting the western suburbs and the circumferential freeway, I-494, with downtown Minneapolis. I-394 was created by converting then existing Trunk Highway (TH) 12, a 4-lane arterial with numerous access points and signalized intersections, to an Interstate Highway. The state legislature approved the conversion, but restricted the size of the new highway to 6-lanes. Comparing projected traffic volumes with different design alternatives, it was concluded that integration of an HOV facility within I-394 would be necessary if the new highway was to be viable. It was further decided that, in order to accomplish the construction of the facility itself, it would be necessary to introduce an HOV lane to TH 12 to mitigate traffic impacts during reconstruction.

The interim HOV lane on TH 12 (referred to as the "sane lane") is an excellent example of the impact potential of well-placed HOV priority treatments in mitigating traffic impact and increasing the efficiency of capital facilities. The interim HOV lane was not a terribly sophisticated facility. The segment of TH 12 over which the HOV lane extended is only about seven miles long. The HOV lane itself covered only a portion of this segment, as shown in Figure 2-2, and was in fact two discontinuous HOV segments making use of the median area. The first segment was about one mile long, merging back into regular traffic for two miles, and then back into the second segment of HOV lane for about three miles. The segmentation was necessary to provide continuity between segments of the new I-394 HOV lane as it was being constructed.

The lane was opened to transit vehicles and pools of two or more occupants. Concurrent with introduction of the lane, a number of other supporting activities occurred, including:

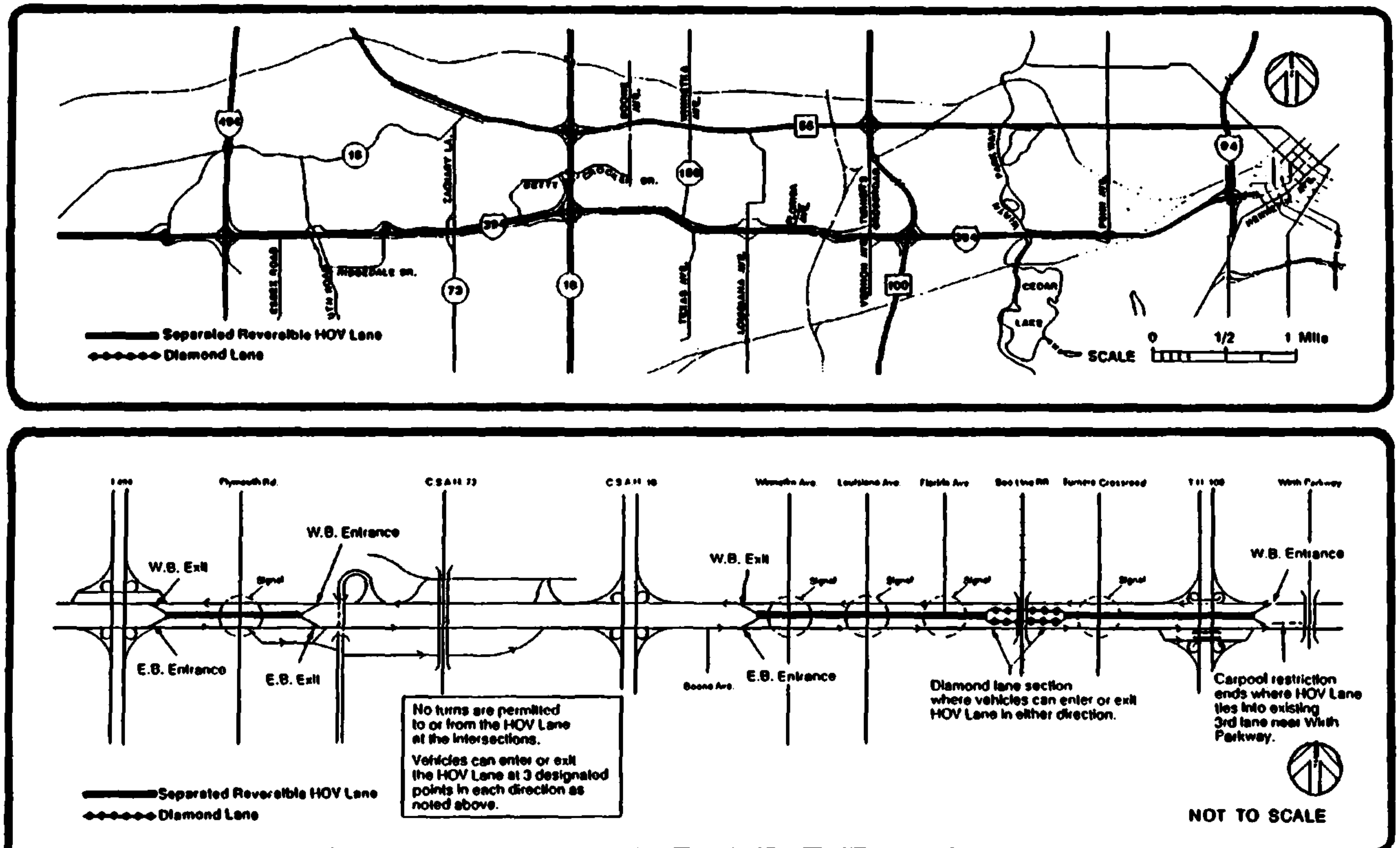
- Opening of two free fringe parking lots for pools downtown;
- Transit service modifications in the corridor;
- Capacity of one of six park-and-ride lots along TH 12 was increased;
- A comprehensive marketing program launched by Minnesota Rideshare;
- Increased surveillance by the State Highway Patrol and fines to enforce the lane; and
- Implementation of an aggressive public relations/public information campaign.

Thanks to a coordinated program, the interim HOV lane worked as intended in shifting travel behavior and mitigating traffic impacts. Despite the segmentation of the lane, measured time savings for users averaged eight minutes. Survey findings suggested that carpoolers *perceived* a time savings of 10 minutes and bus riders a savings of 15 minutes; bad weather greatly increased time savings for all users.

Two important transportation system changes occurred as a result of the introduction of the interim HOV lane:

- First, travelers did respond to the signals posed by the lane by switching travel mode: the percentage of peak period travelers driving alone dropped from 61.9 percent to 48.7 percent, with a significant increase in the rate of ridesharing, from 20.2 percent to 32.8 percent. Interestingly, the increase in ridesharing

Figure 2-2



STRGAR-ROSCOE-FAUSCH, INC.

LOCATION AND SCHEMATIC DESIGN OF THE T.H. 12/I-394 INTERIM HOV LANE

I-394 CASE STUDY

did not come at the expense of transit, where ridership stayed at about 18 percent. This produced an increase in average vehicle occupancy from 1.17 to 1.29.

- Second, because of its improved efficiency, the modified TH 12 attracted travelers from parallel roadways to the north and south, resulting in a 35.4 percent increase in total persons using the highway, while total vehicle trips increased by only 22.6 percent. These reflect significant transportation management impacts.

2.4.3 Pittsburgh East Busway

The Martin Luther King, Jr. East Busway in Pittsburgh, PA, opened in 1983, connects downtown Pittsburgh with its eastern suburbs. It is an exclusive roadway for buses, fully grade separated. The placement of the seven-mile long busway took advantage of excess railroad right-of-way, sharing space alongside Conrail railroad tracks. The East Busway was built and is operated by the Port Authority of Allegheny County (PAT), the primary public transit operator in Pittsburgh, PA.

The plan for a busway in this corridor grew out of increased congestion on the Penn Lincoln Parkway, parallel and to the south. Studies conducted in the 1960's concluded that a busway sharing mainline railroad right-of-way would be both feasible and aligned with travel needs. It was ultimately built with 80 percent federal funding through the Urban Mass Transportation Administration. Some elements of the design were the result of negotiation with the railroad, including provisions for railroad maintenance vehicles. Citizen's groups determined other aspects of busway layout; the configurations of one station and two access roadways were even put to citizen vote.

The Pittsburgh East Busway is a premier example of an HOV facility operated as a form of bus rapid transit, not open to other forms of ridesharing. It includes six stations designed to allow express buses to pass local buses, and several different ramps where bus routes can enter. In Pittsburgh's downtown, the buses circulate on city streets, in part on priority lanes. Two basic types of service are offered on the same busway:

- Diverted Routes: These routes are so called because they existed prior to busway opening, and were shifted onto the busway to produce time savings. More importantly, these and certain new routes collect passengers in the suburbs by operating as a conventional bus route in mixed traffic, and then enter the busway at one of its ramps to run express or with limited stops. Many of the diverted routes formerly used the Penn Lincoln Parkway.

- New Routes: The primary new route is the East Busway All Stops (EBA) which traverses the length of the busway and the downtown loop on a frequent schedule, stopping at all stations. This service is much like a Light Rail Transit (LRT) line, with passengers either walking, or using a connecting bus or auto, to reach stations. Peak EBA service is every four minutes. A second major new route operates similarly, but serves the Oakland employment area east of downtown.

The diverted routes produced transit rider time savings to downtown averaging eight minutes in the morning peak and three minutes in the evening peak. Part of this time savings was from higher bus speeds, and part from improved routing in the downtown. The new EBA route saved patrons 8 to 12 minutes over the previously available bus routes, even though most riders have to make a transfer unnecessary before. Total travel times were reduced by 15 to 23 percent. The time savings made travel better for people who already used transit, including the vast majority of East Busway users, and also attracted new riders from the automobile.

The new routes which cater to walk-ons and transfers at the stations with frequent service have proved especially popular. New routes carry about 13,000 patrons on the average weekday, and the diverted routes another 7,000. The 20,000 weekday total for the East Busway shows that such an HOV facility can attract a high level of patronage, comparing favorably with many Light Rail Transit lines.

Much of this patronage consists of people who formerly used the same or other bus routes. However, 11 percent of new route riders and seven percent of diverted route riders formerly traveled by automobile. Parallel streets and highways are relieved of this automobile traffic and the buses which have been diverted. The East Busway has also stabilized east corridor transit ridership in a period of declining transit use regionwide.

2.4.4 Shirley Highway Busway

The Shirley Highway Busway on I-395 through Northern Virginia into Washington, D.C. has been in operation more than 20 years. The Busway shows how a well designed and located HOV facility can give outstanding transportation service even as conditions change over time. Opened as an exclusive busway during massive freeway reconstruction, it was later opened to carpools and vanpools with four or more occupants. Now it complements and feeds into more recent Metro rapid transit service, and is open to pools with three or more occupants.

Shirley Highway (I-395) serves a congested commuter corridor into downtown Washington and Arlington, VA employment areas. The Busway is an 11-mile, two-lane reversible facility in the center of I-395. It operates in the peak direction of traffic flow, inbound in the morning and outbound in the evening, using sophisticated signing and ramp controls. There are no on-line stations, but exclusive ramps give access to key locations including the Pentagon and its Metrorail station. In response to increasing development extending miles beyond the outer terminus, the HOV facility is now being extended down I-95. This new project will provide a total length of 30 miles.

The present 11-mile Shirley Busway served only buses from partial opening in 1969 until van and carpools were admitted in 1974. During this period bus service was more than doubled with the support of the Shirley Highway Express-Bus-on-Freeway Demonstration Project. At the end of the demonstration, with all freeway construction complete, buses and carpools were saving 19 minutes over mixed traffic during peak morning traffic flow. Bus reliability improved from 33 percent on-time arrival downtown to 92 percent on-time. Carpools and vanpools gained comparable assurance that the trip would be free of major traffic delays. Thus commuters were enticed out of their single occupant vehicles by:

- Substantial time savings;
- Assurance of minimum delay; and
- More frequent bus service.

Success of the Shirley Busway was measured with rigorous studies that looked not just at the overall highway, but of all travelers crossing a four-mile wide corridor, including seven other arterials. Vehicles per person were reduced by 5 percent in the all-bus 1970-1973 period, as measured *corridorwide* in the inbound morning peak period. This reduction, substantial for a four-mile wide swath, jumped to an outstanding 16 percent after introduction of van and carpools in 1974. This reduction was helped along by gas shortages at the time, but has apparently held over the years. In 1988 the facility carried 160 buses during the morning peak one hour, and 2,300 van and carpools.

The Shirley busway benefits from supporting strategies and conditions that are as important as the attractiveness of the HOV facility itself. Research into Shirley Highway corridor travel has shown that:

- Employment of the traveler in the federal government, a supporter of carpooling, is as much an inducement to ridesharing as 12 minutes of HOV facility time savings; and
- HOV parking incentives at the worksite are on average worth eight minutes of HOV facility time savings.

Both formal and informal facilities and systems allow for the staging of people into pools and transit along the Shirley Highway. The express bus system is supported by extensive park-and-ride facilities. A grassroots "instant carpooling" system has developed that allows would-be pools to form on the spot at staging areas. Here individuals seeking rides, and pools needing additional occupants, link up to meet the three-person HOV occupancy requirement. The staging areas were once completely informal but now receive active support.

2.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Preferential HOV facilities work the best by far when supported by other TDM actions. They should be packaged with:

- Transit re-routings and service increases;
- New express transit services;
- Support for carpool and vanpool formation; and
- Incentives and disincentives reinforcing the attractiveness of transit and ridesharing.

Among preferential HOV facilities that can be observed today, most have been introduced together with significant bus service improvements. Most are also radial to a central business district, so transit ridership and carpool formation are enhanced by the parking pricing and supply constraints present to some degree in most downtowns.

Actual experience with preferential HOV facilities indicates that separate roadways for exclusive HOV use, concurrent flow freeway lanes, and contra-flow freeway lanes are all similar in the range of travel time savings afforded HOV vehicles. They produce a range of results in which no one type stands out as being highly unique or different in impact. This suggests that choice of HOV facility type can and should be made to suit local conditions.

In Table 2-2, peak hour bus passenger and vanpool-carpool occupant counts are given for selected HOV facilities in freeways or separate rights-of-way. Also shown is the percent reduction achieved, during the introductory phase, in vehicles per person trip. Note that reductions are given for the transportation facility (freeway) as a whole, or for the four-mile wide corridor where the facility is located.

Table 2-2

Traffic Impacts of HOV Lanes

	1988 Morning Peak Hour Peak Direction Ridership			Vehicles/Person Trip Reduction During Introductory Phase	
Facility	**Bus**	**Vanpool/ Carpool**	**Total**	**Freeway**	**Corridor**
I-495 NJ/NY	34,685	0	34,685	(a)	N/A
I-395 VA/DC Shirley Hwy.	5,621	9,483	15,104	N/A N/A	5% (b) 16% (c)
El Monte-L.A I-10	2,750	4,352	7,102	4%	2% (d,e)
E. Busway, Pittsburgh	5,892	0	5,892	N/A	N/A
I-10 Katy, Houston	1,820	2,595	4,415	11% (f)	N/A
US 290 Northwest Houston	600	3,248	3,848	11% (f)	N/A
I-45N Houston	2,810	416	3,226	20% (f)	N/A
I-95 Miami (g)	350	2,460	2,810	13%	N/A
Minneapolis I-394 (interim)	455	942	1,397	9%	N/A

Notes:

(a) A pre-existing decline in transit ridership was arrested.
(b) First full year of operation through bus-only phase.
(c) First full year of operation through initial operation with van and carpools allowed.
(d) Freeways only (no data for arterials included).
(e) From first partial opening to van and carpools through full opening to van and carpools (does not include impact of original opening to buses).
(f) Representative current value compared to representative pre-transitway value, less the vehicles/person trip reduction observed on freeway without transitway.
(g) 1985 data.

Corridor-wide data give a broader perspective. They include the unaltered highways which parallel the HOV facility, and thus do not include the misleading effect of diversions of pre-existing transit passengers and carpools from these highways to the HOV facility.

The largest reductions in vehicles required per person trip were those obtained with Northern Virginia's I-395 Shirley Highway HOV facility and Houston's I-45N North Transitway:

- The Houston North Transitway reduction of 20 percent was measured on the freeway prior to allowing carpools to use the facility in 1990. Substantial as this is, effectiveness has presumably increased further with introduction of carpools.

- The Shirley Highway *corridor-wide* 16 percent gain in efficiency demonstrates a major, broad-scale TDM impact. It is attributable to many factors; the substantial time savings offered, supporting strategies, and the unique employment base characteristics of the U.S. Capital.

Transit improvements accompanied both of these HOV facility applications, as well as most of the other applications listed in the table. In general:

- A 10 percent decrease in vehicles required per person has been obtained with the more typical HOV facility in freeways or separate rights-of-way, as shown in the table.

- Corresponding *corridor-wide* gains in efficiency are probably on the order of 5 percent.

The New Jersey I-495 approach to the Lincoln Tunnel, although it shows the least percentage impact on vehicles required per person, serves by far the largest volume. In the peak one hour, 34,700 passengers are carried down its single contraflow lane. The very high transit ridership in this New York City commute corridor leaves little margin for mode shifts, but the lane saved riders about eight minutes in the morning peak. It stabilized bus ridership, and allowed a 40 percent increase in auto capacity by shifting buses into the contraflow lane.

The application listed which probably involves the least in transit service improvements or adjustments is the I-394 interim HOV lane in Minneapolis. It benefitted, however, from two downtown parking lots opened by Minnesota Rideshare to provide free parking for registered carpools. The combination of HOV lane and support strategies fostered a 9 percent reduction in vehicles per person, as measured on the facility.

Carpool lanes work best when the highway is completely or largely grade separated, i.e., on freeways and expressways. Some arterial street HOV lanes intended for carpool and vanpool use have been discontinued. However, there are many successful arterial street HOV lanes open only to buses. Arterial bus lanes are not well studied in terms of how many riders they have shifted away from auto use. Often their primary purpose is to resolve traffic conflicts, improve schedule adherence, and allow better transit routings. Where time savings have been of sufficient interest to be reported, they average about five minutes per bus trip.

Exclusive HOV ramps and bypass lanes at metered freeway ramps, operated in conjunction with express bus systems, have combined to attract transit patronage that compares favorably with results obtained on some separate roadways. Results are shown below for I-35W in Minneapolis, a metered freeway with bypass lanes, some of which are for buses only and some of which are for both buses and two or more occupant carpools. In this particular case, auto occupancy did not increase. Gains in efficiency were wholly attributable to added transit ridership.

Table 2-3
Effectiveness of I-35W HOV Lane

1987 Morning Peak Hour Peak Direction Ridership			Vehicles/Person Trip Reduction During Introductory Phase	
Bus	**Vanpool/ Carpool**	**Total**	**Freeway**	**Corridor**
2,630	1,510	4,140	12%	2%

Over 90 California ramp meter bypasses, mostly in the Los Angeles region, have resulted in average time savings of one and a half minutes and an average increase in carpool volume of 25 percent. Prime locations have achieved a doubling of carpools, split about 50-50 between new carpools and preexisting carpools changing route. Individual ramp meter bypass lanes, toll plaza bypass lanes and exclusive HOV ramps can give buses and pools a time advantage of one to five minutes and even more, depending on circumstances.

2.6 COST EFFECTIVENESS

The cost effectiveness of preferential HOV facilities derives primarily from shifting former drive-alone commuters to buses, vanpools and carpools. While the benefits of reducing vehicle trips and vehicle miles of travel (VMT) per traveler are common to TDM programs in general (discussed in Part III), there are some unique aspects to HOV facility cost effectiveness, which are explored here.

Energy savings and vehicle emission reductions are, of course, expected from preferential HOV facility implementation. Energy use and pollutant emissions are affected by the VMT reductions attainable with HOV facilities and also by changes in traffic flow conditions:

- Separate HOV facility, "add-a lane," and most contra-flow lane projects inherently result in automotive fuel savings per person-trip served because of simultaneous reduction in vehicle use and improvement in overall traffic flow. The improvement in overall flow is achieved in part through providing of freeing up additional lanes where needed.

- "Take-a-lane" projects, because non-priority traffic may be slowed, may not save energy or lower emissions even though VMT is reduced.

The effectiveness of Houston's "Transitway" on the Katy Freeway was analyzed by comparing the actual HOV facility with the hypothetical alternative of adding another mixed-flow traffic lane instead. Simulation showed that the Transitway option produced an average speed of 41 mph for all traffic (HOV plus regular traffic) as compared to 38 mph for the mixed-traffic lane alternative. Vehicle miles of travel were roughly 10 percent less, the fuel savings was just over 10 percent, and pollutants emitted were 10 percent to 20 percent less.

Preferential facilities offer HOV travel time savings that probably average five to ten minutes for most major facilities. If the average annual travel time savings is at least 10 percent of the construction cost of a project, as a rough measure, the facility is cost effective based on the value of time savings alone. Houston's North and Katy Transitways, the Houston facilities in operation the longest, are shown to be cost effective considering nothing more than the travel time savings.

2.7 IMPLEMENTATION ISSUES

HOV facilities are typically implemented by public agencies, because they are major public works facilities. The potential exists, however, for private or non-profit authorities to construct and operate HOV facilities, along the lines of a toll road. In fact, through discriminatory pricing strategies, the granting of either toll discounts to HOVs or charging toll premiums to SOVs could result in a facility which operates somewhat like a preferential HOV facility. There are no known instances where preferential HOV facilities have been built or operated by individual employers (or developers), but the potential clearly exists in the form of exclusive ramps or interchanges.

The primary issue in developing the support basis necessary to build and maintain an HOV facility is that objectives be coordinated among the various entities. Most particularly:

- The traveling public, even in highly congested travel corridors, may not initially embrace HOV facilities as a solution; typically they see the solution in the provision of new highway capacity, and resent any restrictions on the use of that capacity, even if it supports their well-being.

- Elected officials, sensing the mistrust of the public and the business community, may not see HOV facilities as supportive of their economic development or political goals.

- Communities or jurisdictions may disagree with each other on an HOV facility which affects each of them differently.

- Agencies may disagree on the benefit or desirability of HOV lanes; transit agencies may feel that HOV lanes near a fixed guideway transit line will sap its ridership, or that carpools will compete with regular route transit service.

Resolution of these issues begins with good planning and information. Individuals need to be apprised of the costs and benefits of the HOV lane, first of all to accept it as a transportation management strategy, and second to be persuaded to use it. Information programs can be effectively developed to perform this function.

The acceptance of HOV lanes can also be buffered significantly by the manner in which they are introduced:

- Obviously, *adding* a lane to an existing facility and proclaiming it as HOV-exclusive is likely to provoke less public resistance than if a lane is *taken away* from existing capacity.

- Letting the public know well before the opening of a facility that it will be HOV exclusive (or some day will be HOV exclusive) is less likely to produce a reactionary shock when the event occurs.

- If it appears that it will take a while for lane usage to build to design levels, it may be necessary to initiate operations with a modest minimum occupancy requirement, i.e., HOV-2 instead of HOV-3 or 4. This can be adjusted over time to provide the appropriate balances between efficiency and utilization.

- Developing complementary programs to support use of the lane is important; these include, as appropriate, transit service improvements, carpool/vanpool programs, rideshare/transit staging or park-and-ride areas, parking management programs, and relevant financial incentives or disincentives.

- Enforcement is very important, not only to ensure the continued high performance of the facility, but to give it public credibility that its integrity and dedicated use will be maintained.

Programming HOV facilities also relies significantly on available resources, and being able to dedicate those resources toward an HOV project. Agencies, or the elected bodies that direct the agencies, may see alternative projects for the resources that would be used for HOV lanes. Increasingly, federal and state funding programs and regulations (such as the Federal Clean Air Act, Congestion Management System requirements, and local traffic mitigation ordinances) may place higher priority on the inclusion of HOV facilities in state and regional transportation system plans.

2.8 REFERENCES

For more information in preferential HOV facilities, the following references are of particular value:

William Barclay Parsons Fellowship Monograph 5, Charles A. Fuhs, *High-Occupancy Vehicle Facilities*, 1989 Parsons Brinckerhoff, October 1990 is a comprehensive guidebook on current planning, operation and design practices for HOV and busway applications in freeway corridors and on exclusive rights-of-way.

Texas Transportation Institute, *A Description of High-Occupancy Vehicles in North America*, Technical Report 925-1, July 1990 is a compilation of descriptions, operating data, costs and usage volumes for all of the HOV facilities on freeway or separate rights-of-way in North America as of 1988.

National Highway Research Program, *Bus Use of Highways*, Report 143, Transportation Research Board, 1973 covers all types of installations and remains the most comprehensive source for information on arterial street bus lanes.

Second Edition, U.S. DOT, Federal Highway Administration, *Traveler Response to Transportation System Changes*, July 1981 provides detail, in the "Pool/Bus Priority Facilities" topical digest, on the successes and failures that helped build our "how to" and "how not to" knowledge base.

Texas Transportation Institute, *The Status and Effectiveness of the Houston Transitway System, 1989,* Technical Report 1146-2, March 1990 provides a particularly comprehensive evaluation of the implementation, operation and results of a preferential HOV system network.

Guide for the Design of High Occupancy Vehicle Facilities, 1992, American Association of State Highway and Transportation Officials provides a comprehensive overview of the design details that lead to successful HOV facility development.

Strgar-Roscoe-Fausch, Inc. *I-394 Interim HOV Lane: A Case Study, 1987,* for the Federal Highway Administration documents the development, operation, and initial use of the I-394 HOV lane in Minneapolis. The interim HOV lane was a temporary feature of a major highway reconstruction intended to both ease construction impacts as well as condition travelers to future HOV requirements in the subject corridor.

B.3 ECONOMIC INCENTIVES

3.1 DESCRIPTION OF STRATEGY

Two key factors in a traveler's decision to use one mode over another are the relative time and costs. Given the overwhelming advantage of the single-occupant vehicle (SOV) in most modern suburban travel situations, incentives are critical in any attempt to shift travelers into alternative modes of travel. This section discusses the nature and effectiveness of economic incentives. These incentives are offered as encouragement to carpoolers, vanpoolers, transit riders, walkers, bicyclists, travelers and those who change the timing or location of their trip by means of alternative work hours or telecommuting. Financial incentives offered directly to travelers by employers or public agencies, termed *user subsidies*, are the focus of this section. Tax incentives offered to employers, or public subsidies provided to service providers to promote or provide alternatives, are not considered incentives under this definition, and hence are not discussed here.

Travel Demand Management (TDM) incentives are most often applied to work trips. These can include incentives to use specific alternatives, such as transit or vanpooling, or more flexible incentive schemes that provide subsidies to users of any alternative commute modes, such as rideshare subsidies and travel allowances. Recent studies have concluded that subsidies are a frequently present component of effective employer trip reduction programs ("*Trip Reduction Effectiveness of Employer-Based Transportation Control Measures: A Review of Empirical Findings and Analytical Tools*," Schreffler, Eric N.; Kuzmyak, Richard, COMSIS Corporation, Paper before the 84th Annual Meeting of the Air and Waste Management Association, June 1991). Most commonly, subsidies are provided by employers who, motivated by local trip reduction requirements, need to reduce parking demand or to alleviate access problems. Alternatively, public agencies may offer subsidies to travelers to achieve localized or area-wide trip reduction goals.

While financial incentives come in many forms and can be tailored by employers and public entities to various travel markets and situations, some of the more common subsidy schemes include:

EMPLOYER/DEVELOPER-PROVIDED INCENTIVES

- ***Transit Pass Subsidies:*** employer/developer total or partial purchase of transit passes, tickets or tokens for employee use. In some cases, the employer purchases monthly passes and sells or gives the pass to employees. In other cases the employer agrees to reimburse employees for their purchases. A 1990 survey of U.S. transit operators revealed that over 60,000 employees receive subsidized passes from their employers in 10 cities (*"Employer Provided Transit Passes,"* KPMG Peat Marwick, for the U.S. Department of Transportation, UMTA, Office of Budget and Policy, November 1990). A 1983 survey of employers revealed that 10 percent of all firms distribute transit passes and two-thirds of these subsidize the passes (*"Employer Involvement in Employee Transportation,"* Wagner, Daniel W; Schuefran, Oliver, Peat Marwick, Mitchell & Company, for the U.S. Department of Transportation, TSC, Report No. UMTA-MA-06-0049-85-14, June 1985). In Boston, 130 of the 800 employers participating in the pass program provide subsidies to over 10,000 commuters (*"Transportation Demand management in the Northeast: Catalog of TDM Techniques,"*, Northeastern Association of State Highway and Transportation Officials, April 1991).

- *Vanpool Operating Subsidies:* Vanpool subsidies can take many forms. Employers that provide the vehicles, underwrite insurance and capital costs or help employee groups arrange vanpool leases are providing an "in-kind" form of financial incentive. These incentives are covered in Section 3.4. Direct subsidies to users of vanpools, no matter who owns, leases or operates the vans, are covered in this section. Vanpools generally serve long-distance commuters, and since vanpool fares are usually distance-based, the monthly fare can be substantial, often ranging from $50-100. Employer subsidies help defray the out-of-pocket costs of vanpooling by subsidizing employees through:

  - free or subsidized fares for the first one to six months of usage;
  - monthly subsidies or one to two free months per year for "loyal" riders;
  - free fares and use of the van by the driver.

Fourteen percent of employers, according to a 1983 survey, offer vanpooling as a program element. Of these, most involved no fares for the driver and one quarter subsidized the fares (*"Employer Involvement in Employee Transportation,"* Wagner, Daniel W; Schuefran, Oliver, Peat Marwick, Mitchell & Company, for the U.S. Department of Transportation, TSC, Report No. UMTA-MA-06-0049-85-14, June 1985). Therefore, most employer-sponsored vanpool programs, and all owner-operators vans, operate without user subsidies. Of course, this does not include public sector subsidies and tax credits.

- ***Rideshare Subsidies:*** Rideshare subsidies generally involve a broader subsidy scheme by offering a user subsidy to any employee using a commute alternative, not just transit or vanpool riders. Rideshare subsidies, offered on a daily, pay period, monthly, or annual basis, represent a means to more equitably implement a financial incentive by allowing employees to choose the alternative that best suits their travel needs, and then apply the rideshare subsidy to that mode. Sometimes the subsidy increases with the occupancy of the alternative, i.e., transit users and two-person carpools get a smaller subsidy than those in larger carpools or vanpools. Another subsidy scheme involves a uniform monthly subsidy equally applied to any commute alternative. The 1983 survey of employers cited above reveals that 32 percent of respondent firms had a rideshare program and 13 percent of these provided rideshare subsidies of some form ("*Employer Involvement in Employee Transportation,*" Wagner, Daniel W; Schuefran, Oliver, Peat Marwick, Mitchell & Company, for the U.S. Department of Transportation, TSC, Report No. UMTA-MA-06-0049-85-14, June 1985).

- ***Travel Allowances:*** Whereas rideshare subsidies apply to users of commute alternatives, travel allowances represent a monthly stipend for employees to use on whatever travel mode they wish, including driving alone. Travel allowances are most often tied to parking charges whereby employees can apply the allowance to all or part of their parking fees, or use the allowance to purchase a bus pass or share the cost of commuting in a carpool or vanpool. For employees who bicycle, walk, or are dropped off at work, the allowance becomes a windfall.

  Another form of travel allowance is a differential parking subsidy that provides higher allowances to users of commute alternatives and/or higher parking subsidies for higher occupancy levels ("*A Review of Transportation Allocate Programs,*" Bhatt, K., K.T. Analytics, Inc., Paper before the 70th Annual Meeting of the Transportation Research Board, January 1991). Again, these allowances differs from rideshare subsidies in that they apply in some form to all employees, with solo drivers receiving the lowest subsidy. For example, solo commuters might receive a 50 percent parking subsidy, two-person carpools a 75 percent subsidy, three-person and more pools receive a 100% parking subsidy, and transit users and others receive a subsidy for all or part of their commute expenses.

- ***Other Financial Incentives:*** Other financial incentives that provide a real, monetary incentive to using alternative travel modes do not involve direct subsidy payments to users. These include:

  - use of fleet vehicles for ridesharing;
  - free or discounted fuel for pooling vehicles;
  - free or discounted maintenance and repair for pooling vehicles;
  - extra vacation for commute alternative users;
  - free or discounted equipment (shoes, bicycle helmets).

The use of fleet vehicles generally involves employers with existing fleets (utilities, sales, public service) allowing employees to use these vehicles for pooling purposes by taking vehicles home at night. In addition, these employers must address the insurance issue of commuting use of the vehicle. Subsidized fuel or maintenance generally involves utilizing on-site motor pool services or contracted arrangements with gas stations or repair shops. Sometimes commutes are reimbursed for a monthly gasoline allowance as an added incentive to ridesharing. Extra vacation is provided in lieu of cash subsidies at some firms whereby employees receive, for example, one to two days extra paid vacation per year for ridesharing a specified number of days. Finally, free or discounted equipment may be viewed as more of a prize or giveaway, but when tied to use of an alternative does defray the out-of-pocket costs. Such equipment has included walking shoes, bicycles, bicycle helmets, emergency road-side kits, etc. One firm in Los Angeles provided bicycles to commuters and gave them to the employee after six-months use for commuting ("*f*ACTs, published by the Southern California Chapter, Association for Commuter Transportation, Volume 6, Issue 8, October 1991).

PUBLIC AGENCY PROVIDED INCENTIVES

- ***Transit Fare Discounts:*** While most public transit service is subsidized, the ability to directly subsidize users most often involves the reduction of fares for all users or targeted user groups (commuters, students, elderly, etc.). Fare discounts targeted to commuters are fairly rare, because commuters represent "choice" riders (i.e., having a choice of commute options); service is generally the most costly to operate during the peak periods; and premium express-type commuter service most often commands a fare surcharge, not a decrease. However, the ability to increase transit ridership, and therefore reduce trips, by decreasing transit fares is discussed in this chapter. In some cases, transit operators have experimented with free fares to increase ridership ("*Traveler Response to Transportation System Changes, 2nd Ed.,*" Pratt, Richard H.; Copple, John N., Barton-Aschman Associates, Inc., R.H. Division for the U.S. Department of Transportation, FHWA, July 1981).

- ***Transit Subsidies:*** While "user-side subsidies" are prevalent in elderly and handicapped services, some limited examples exist of public sector agencies offering commuters direct subsidies for using transit. In some cases (see examples below), cities or counties match employer transit subsidies. In other cases, transit operators sell passes to employers at a discounted rate if the employer in turn subsidizes the passes (in effect, the equivalent of a subsidy match). Finally, some public agencies have provided free ride tickets to commuters to use transit on a trial basis.

- ***Vanpool Start-up Subsidies:*** As with tickets for trial use of transit, some public agencies have subsidized the start-up costs of vanpools. This is accomplished by either providing a one-time start-up incentive to new vanpools or subsidizing all or part of an individual's vanpool fare for the first few months of operation. In California, vanpool start-up subsidies have been used in conjunction with highway reconstruction projects, to mitigate the impact of delays and hassles on commuters by providing an alternative to driving alone.

3.2 NATURE OF EFFECTIVENESS

Automobile users realize a daily *operating cost* linked to the length of the trip, plus any *out-of-pocket costs*, such as bridge tolls or parking fees. Since such daily out-of-pocket costs are experienced by only a small proportion of travelers, given the preponderance of free parking and toll-free facilities, the operating costs of a single-occupant vehicle are often the only costs considered by travelers. These operating costs are often reduced to the cost of fuel, given that studies show that most travelers ignore long-run fixed costs such as capital, maintenance and insurance. This is largely because payments for long-run costs are not paid on a daily or weekly basis, as are fuel, parking and tolls, but are tied to the vehicle ownership decision itself.

Transit users, by contrast, must pay a fare to travel, which in most U.S cities is greater than the out-of-pocket fuel costs for driving. Carpool and vanpool users can split the cost of operating the vehicles, and such cost savings are cited by users as an important reason for sharing a ride. The cost savings alone from sharing a ride, however, are generally not enough to overcome the travel time disadvantages of ridesharing over SOV use.

Therefore, cost incentives for use of travel alternatives ("carrots" such as subsidies and allowances) and SOV cost disincentives ("sticks" such as parking fees and tolls) are utilized to change the "economic equation" to make HOV modes more attractive as an alternative to driving alone. In fact, some studies show that an equivalent HOV subsidy has approximately the same effect as a surcharge on driving alone. In other words, a dollar subsidy for ridesharing has a similar effect as a dollar parking charge for solo drivers ("*MAG Congestion Management Study: Task 8 Working Paper - Market Incentives,*" for the Maricopa Association of Government, November 1991). This is a profound finding in that positive reinforcing incentives can be as effective as charges and fees that are negatively perceived as a penalty.

Essentially, a direct subsidy to travelers or to ridesharers, forces users to make an economic decision on a daily, weekly or monthly basis. For example, commuters might perceive ridesharing subsidies as a financial "reward" for using a commute alternative. Similarly, a travel allowance forces commuters to make a monthly economic decision concerning the use of the allowance. If the subsidies and allowances are structured properly, the relative advantage of using a commute alternative will be apparent to the employee and cause the intended shift from SOV to HOV and non-motorized modes.

3.3 APPLICATION SETTING

Financial incentives and subsidies seem to work best as a TDM strategy under the following conditions:

TRAVEL MARKETS

As with most TDM strategies, the typical travel market to which financial incentives are applied is the home-based work trip, or commute trips. In the case of financial incentives, inducements are clearly needed to shift commuters who generally have access to an automobile, into non-SOV arrangements. In the case of transit usage, the "choice" riders often need a financial incentive to use transit, because service characteristics alone (premium, express service, ability to read and relax, etc.) are generally insufficient to induce existing solo drivers to switch.

As evidenced by U.C.L.A.'s extensive TDM program, some educational institutions subsidize carpool, vanpool and even transit usage among employees (*Effectiveness of TDM Actions,* FHWA, 1990). This is most often done to relieve parking supply constraints because few trip reduction regulations apply to school-based trips.

In non-commute travel markets, travelers are already traveling in higher-occupancy modes at higher rates. For example, shoppers, students, elderly and handicapped (E&H) travelers tend to share rides out of convenience or necessity, rather than based on the relative cost of driving alone versus ridesharing. Transit fare discounts and user subsidies for students and E&H travelers are more often based on social goals tied to mobility than trip reduction goals tied to traffic or air quality. Merchant discount tickets and off-peak fare discounts are used to entice travelers to shop during certain periods of the day or at certain locations, but are more likely to create new demand rather than shift demand from SOV use during the peak period.

TRAFFIC CONDITIONS

It is more likely that financial incentives will be offered in an environment where traffic congestion has reached or is likely to reach a serious level. While congestion alone may not be sufficient to press commuters into alternative modes/behaviors, it may cause either employers to take actions involving incentives, or governments to design ordinances which compel employers to implement trip reduction programs with incentive measures.

SUPPORTING STRATEGIES

Clearly, subsidy schemes must be tied to a package of TDM program elements to be successful. Commute alternatives, such as vanpool provision and transit services, must be available. However, some clear supporting elements are also needed.

- *Rideshare subsidies are most effective when combined with parking surcharges for SOV users.* Either independently or through travel allowances, parking charges force commuters to make mode choice decisions, and when commute alternatives are reinforced with specific subsidies, the impact is greatest. Also, the parking revenues help pay for the subsidies.

- Subsidy schemes still need to be *supported by strong marketing, promotion and corporate backing.* As much as financial incentives cause commuters to make rational economic decisions on a on-going basis, if employees are unaware of the incentives, the alternatives and the management support for using an alternative, overall program effectiveness will be diminished. This is particularly an issue when program effectiveness is considered over time. If not constantly reinforced, new and existing employees will not participate.

3.4 EXAMPLES

The reader should remember that with any TDM strategy, the ability to separate out the effects of any individual strategy from an overall package is severely limited by the data. However, in the case of financial incentives, the following examples have been selected to try to show the effect of programs where incentives have had a key role. The detailed employer examples provided below include one example of a firm where employees encounter both parking charges and a travel allowance (San Diego Trust & Savings) and a firm with free parking that offers a rideshare subsidy only (Union Bank).

3.4.1 Employer/Developer Sponsored Incentives

San Diego Trust & Savings

San Diego Trust & Savings represents an employer with an extensive financial incentive scheme for all employees, those who drive alone and those using commute alternatives. San Diego Trust & Savings is a large full-service bank headquartered in downtown San Diego. In 1972, it implemented commuting benefits for its 500 downtown employees to equalize commuting benefits provided to employees at different work sites. Employees at its suburban locations received free parking. Downtown employees were not provided with parking, free or at cost. Therefore, the bank initiated transportation subsidies for downtown employees. Employees who drove to work received a parking subsidy, with carpoolers receiving a higher subsidy than drive-alone commuters to encourage ridesharing. Employees also were given the option of a 100% transit subsidy, if they preferred to commute by public transportation.

In late 1988, the bank decided to increase the transit subsidy to 125% of the employee's cost, in response to federal tax legislation that changed the designation of employer-provided transit subsidies over $15 per month to a taxable fringe benefit. Under this legislation, parking subsidies continued to be tax free, thus the bank did not increase the value of the parking subsidy. Current market rates for parking range from $90 to $120 per month in a commercial garage, about twice the subsidy now provided to drive-alone employees.

In May 1991, the bank's commuter program, based on a travel allowance by commute mode, included the following primary elements:

- Transportation subsidy:
  - $55 per month for solo drivers (approximately 1/2 market rate)
  - $70 per month for employees in two-person carpools (each employee)
  - $100 per month for employees in three-person carpools (each employee);
- 125% transit subsidy (average of $60 per month);
- Rideshare matching through the regional ridesharing agency;
- Flexible work hours by arrangement of individual departments.

To receive the transportation or transit subsidy, employees complete a form each month that indicates the commute mode they used. Employees receive the subsidy in one of their bi-weekly paychecks. The forms are completed on the honor system and are not audited.

The program is managed by a part-time, on-site Employee Transportation Coordinator (ETC). The ETC promotes commute alternatives through employee orientation, on-site information boards, and several special promotions during the year. Management support for the commute program has been quite strong. Although the bank has been required since 1989 to comply with a City of San Diego trip reduction ordinance, the bank began its program voluntarily, as a service to employees, and management has been sensitive to employees' need for flexibility.

Data for years prior to 1989 are not available, thus it is not possible to measure how the subsidy program initially affected commute behavior. The bank did conduct surveys, however, in 1989 and 1991, that show an increase in transit and carpool use during the 1989 to 1991 period, following the increase in the transit subsidy from 100% to 125%. Data were also available to compare commute mode split and vehicle trips per 100 employees (VT/100) for San Diego Trust & Savings employees with the same statistics for other downtown banks and with the averages for 121 other CBD companies. These impacts are summarized in Table 3-1.

TABLE 3-1

Comparison of Mode Shares in Downtown San Diego

Mode of Travel	San Diego Trust (1989)	San Diego Trust (1991)	Downtown Firms	Downtown Banks
Drive Alone	55%	44%	60%	65%
Carpool	10%	14%	14%	14%
Vanpool	0%	0%	1%	1%
Transit	32%	37%	19%	17%
Other	4%	5%	6%	1%
Vehicle Trip Rate*	**60**	**51**	**66**	**71**

* Expressed as the number of vehicle trips to transport 100 travelers.

Table 3-1 shows that between 1989 and 1991, the bank reduced its drive-alone rate from 55 percent to 44 percent. The number of vehicle trips per 100 employees declined from 60 trips to 51, a reduction of 15 percent. Employees shifted to carpooling and to transit in approximately equal numbers, suggesting the carpooling and transit subsidies were equally attractive, even though only the transit subsidy amount had changed.

A comparison of the bank's commute statistics with the average for 121 downtown companies shows substantially lower drive alone and vehicle trip rates among San Diego Trust & Savings employees. As compared to the average mode split for all downtown firms, which exhibit a drive alone share of 60 percent and a VT/100 employees rate of 66, the bank's program has reduced trips by 23 percent. When comparing San Diego Trust & Savings to other downtown banks (six firms) exhibiting a drive alone rate of 65 percent and a VT/100 employees rate of 71, San Diego Trust & Savings has reduced trips by 28 percent.

The San Diego Trust & Savings example provides strong support for the effectiveness of financial incentives. A 23 percent to 28 percent trip reduction, when compared to other banks or downtown firms, is impressive. Of course, employees of the bank are also faced with paying for parking, albeit receiving a partial subsidy. The key to the success for the banks program is the strategic levels at which subsidies are set. Carpoolers have their commute subsidized at a higher level than solo drivers and transit users get their entire commute subsidized, including the taxes that need to be paid.

Union Bank - San Diego

By way of comparison, Union Bank is an employer that provides a financial incentive, but also offers free parking to employees. Union Bank is located in downtown San Diego, close to San Diego Trust & Savings. The bank, with 315 employees, offers employees a 100% transit subsidy. Employees are also offered free, although off-site, company-leased parking in a garage located several blocks away. Monthly garage pass holders are also given passes to the downtown trolley service, which connects the garage to the office.

Union Bank has a vehicle trip rate of 58 trips per 100 employees and a transit share of 36 percent, equal to SDTS's and substantially higher than the CBD average. This transit share equates to a 15 percent trip reduction when compared to all downtown employers.

Other Employer Examples

- <u>Rideshare Subsidies</u>

  While most employers provide subsidies on a monthly basis, the **County of Ventura** provides its employees an annual financial incentive of $200 to $300 based on the number of days they use an alternative to driving alone ($200 = 2 times per week for 48 weeks and $300 = 3 or more times per week). The County's drive alone rate fell to 69 percent (from 87 percent) after introduction of the annual subsidy for a trip reduction of 13 percent over pre-program rates.

- <u>Vanpool Subsidies</u>

The **Jet Propulsion Laboratory** in Pasadena, CA provides a $15 per month subsidy to vanpools and $250 start-up seed funding. The employer also supports the program by fueling and washing the vehicles, providing a preferential parking space and a guaranteed ride home program. Since the program's inception (in response to a regional trip reduction ordinance) in 1989, over 30 vans have been formed and the share of employees vanpooling has risen from 1 percent to 6 percent. JPL vanpoolers also benefit from various state and county vanpool subsidy and tax credits. The average net vanpooling expenditure per employee per month is about $20 as compared to average fares three to four times that amount ("*Seminar of the Southern California Chapter*, of the Association for Commuter Transportation, Courtney, Joe H., Jet Propulsion Laboratory, October 1991).

- <u>Travel Allowances</u>

Perhaps the purest form of a travel allowance is one that sets the subsidy at the monthly cost of parking and then allows employees to decide on whether to buy back the space or use a cheaper alternative and pocket the difference. **CH_2M HILL** in Bellevue, WA, relocated to a site with limited parking, but leased parking spaces for those employees wishing to buy a space. The travel allowance is $40 per month, equal to the lease cost. Ridesharers receive the allowance and free parking while transit users get a subsidized transit pass in addition to the allowance. The firm's drive alone rate fell from 89 percent to 54 percent for an overall trip reduction of 31 percent. ("*A Review of Transportation Allocate Programs,*" Bhatt, K., K.T. Analytics, Inc., Paper before the 70th Annual Meeting of the Transportation Research Board, January 1991).

- <u>Differential Parking Rates for Ridesharers</u>

While employee parking charges are discussed in Section II B.4, a significant number of employers provide reduced rates for ridesharers when they did charge for parking. In fact, 15 of the 25 employer programs investigated in this study included parking charges for employees. Of these programs, eight provided discounts for ridesharers or provided free spaces to carpools and vanpools. For example, **Hartford Steam Boiler** charges employees $110 per month to park, the market rate for spaces the employer leases. Carpools with two persons are charged $75; three persons $37.50 and four or more charged $10. In addition to the lower fees, ridesharers can split the cost of parking so that each is paying a maximum of $37.50 as compared to the SOV rate of $110. (FHWA, *Effectiveness of TDM Actions in Alleviating Traffic Congestion*, 1990.)

- Other Financial Incentives

  Some employers provide ridesharing incentives that provide a direct financial benefit to the commuter, rather than cash subsidies. For example, **San Diego Gas & Electric** provide employee groups with fleet vehicles for use in ridesharing. The **City of Pasadena** reimburses employees for bicycle ($100) and helmet ($50) purchases. Perhaps one of the more interesting incentives is provided by **Allergan** in Irvine which offers employees one to two extra paid vacation days per year for ridesharing on a regular basis (two to three days per week or more). While Allergan provides transit and vanpool incentives as well, the firm's drive alone rate is lower than the county-wide average (76 percent versus 86 percent) for an overall trip reduction of almost 8 percent.

3.4.2 Public Agency Sponsored Incentives

While most financial incentives offered to commuters are provided by their employer, some examples exist of public agency financial incentives and programs that augment employer subsidies or programs. Two examples of transit fare incentives are provided below. One involves a set of subsidies and "match" provided by a government agency to commuters and their employers (Montgomery County). The other example involves the provision of new express service to a set of hospitals in exchange for a guaranteed purchase of passes and employee subsidy by the employers. Additional examples are cited on vanpool subsidies and transit fare reduction and incentive programs.

Montgomery County Rideshare Incentives

The Montgomery County Ridesharing Office provides several programs whose intent is to reduce single occupant travel within the County. The Ridesharing Office operates a set of programs designed to increase the average vehicle occupancy (AVO) within the County. One part of this program is a ride-matching service, linked to the regional planning agency, and traditional rideshare promotions. Additionally, for work trips, the program provides incentives for vanpooling, carpooling, and transit use. These incentives, provided to commuters and employers, are unique among public agency programs.

The Ridesharing Office provides three basic incentives:

(1) "Fare Share", a transit fare incentive program;

(2) Parking Subsidies and preferential parking for carpoolers; and

(3) "Fare Share" capital start-up subsidy for vanpools.

Each is described below.

- Fare Share Transit Subsidy

  The Fare Share program provides discount transit passes to people who work in the County. For employers that opt to participate, Fare Share requires employer participation in administering as well as funding the discount passes. The County and the employer each provide a 25 percent subsidy. Employers purchase the discount passes directly from the County, at a cost to the employer of 75 percent of the face value. The employers then sell the passes to their employees for 50 percent of the face value. The employee therefore receives a 50 percent fare discount, and can purchase the pass directly from the employer.

  Employers are responsible for determining how many passes to purchase, providing funds to purchase from the County (i.e., cash outlay) as well as for the employer portion of the subsidy, and handling the cash transactions associated with selling passes to employees. Employers also report the number of program participants to the County.

- Parking Subsidies

  Montgomery County public parking facilities have preferential spaces set aside for car- and vanpools. These spaces are clearly labelled, and signs are posted throughout the lots to inform non-poolers about the program. In addition to having priority spaces set aside, car- and vanpoolers pay a discounted rate for parking. Like Fare Share, discount parking permits are sold through employers who purchase the permits from the County and resell them to employees. Employers, however, are not required to contribute towards the parking permit subsidies. The County funds the entire subsidy.

  When a carpool or vanpool is formed, the members of the pool submit a form to the County to register as a valid pool. The information includes the names, home address, and work address of all pool members. After verifying the member's participation, the County authorizes the pool as a valid participant in the parking program.

  The pool is then eligible to purchase the monthly discount parking permit associated with the number of people in that pool. The regular undiscounted monthly rate at the County garages is $65. Two-person pools purchase monthly permits at the discounted rate of $60. Three and four-person pools pay the discounted rate of $30. And pools with five or more members receive a free parking permit.

The priority pools spaces are reserved until 9:30 a.m., after which time they can be used by the general public. Pools can always use any long-term parking space in the parking garage for which their permit was issued. The number of spaces reserved for pools varies with program participation levels; sufficient pool spaces are always provided.

- <u>Vanpool Subsidy</u>

To encourage HOV pooling, the County offers a one-time vanpool subsidy program for vanpools with at least eight new passengers. The subsidy amounts to $2,100.00 over 18 months. The individual who owns or leases the van being used submits an application to the County. If the vanpool in fact has at least eight passengers new to the pool, and if the pool uses the specified roadways (if traveling from outside the area, vanpools must use either I-270 or US 29), the pool qualifies for the subsidy. After signing a contract with the County, the van owner/lease holder receives monthly subsidies from the County on the following schedule:

Months 1-6	$200/month
Months 7-12	$100/month
Months 13-18	$ 50/month

After the 18-month period, the vanpool is no longer eligible for subsidy unless it enlists eight new members.

While the impact on traffic congestion or trip reduction has not been quantified, a surrogate measure of success is the number of participants in each program. The Fare Share Program, providing subsidies to transit users, has attracted a total of 1,310 new transit riders during the program's first four years. As seen in Table 3-2, program participation rates, in terms of employers and transit riders, has grown substantially.

Assuming an occupancy for transit of 30, the 2,318 program participants in 1990 generated an average of 77 daily vehicle round-trips (this assumes that all participants use transit full-time; data on actual transit usage rates were not available). This represents a reduction of 1,855 daily vehicle round trips, assuming a base AVO of 1.2. More recent information shows that 110 employers and 2,700 employees were participating as of 1991. The program cost the County approximately $45,000.

In 1991, the County sold approximately 500 carpool parking stickers monthly. These carpools translated to an AVO of 2.85. This represents a reduction of almost 700 daily vehicle roundtrips, assuming a base AVO of 1.2.

TABLE 3-2

Fare Share Program Participation

Fare Share	1987	1988	1989	1990
Participating Employers	3	53	65	70
New Transit Riders (cumulative)	23	662	1,294	1,310
Total Transit Riders	559	1,545	1,650	2,318
Fare Media Sales	$18,528	$293,955	$657,875	$1,082,581

Finally, the vanpool subsidy program has subsidized 22 vanpools over the life of the program, although only eight of these vanpools have completed the 18-month subsidy program. At a cost of $2,100/vanpool and a minimum of eight new passengers, the maximum subsidy per passenger under this program is $14.58/month/passenger, or $175/year.

As a footnote, budget constraints in Montgomery County caused the incentive programs to be discontinued. The ridematching and promotion element is still in place, but the provision of direct subsidies to employers and commuters has been discontinued. Program administrators report that approximately half of the participating employers discontinued their pass programs and only a small proportion of remaining firms increased their subsidy to account for the loss. However, the ability to leverage employer subsidies through the Fare Share program contributed to a measurable increase in transit use among Montgomery County commuters and some of that increase may be maintained beyond the program's lifetime.

First Hill Express Service - Seattle

The First Hill Express Service represents an innovative example of a public/private partnership created so that employers could address parking problems and comply with a city ordinance by providing a new commute alternative and providing financial incentives for its use.

First Hill is a 10-block area just east of downtown Seattle that includes seven medical institutions, a university and several medical office buildings. The daytime population is over 15,000. While transit service from downtown Seattle is good, service from outlying areas require a transfer downtown, adding to long commutes. The institutions all faced the City of Seattle trip reduction requirements placed on development and expansion of major institutions.

Seattle Metro, the regional provider of transit and ridesharing services, worked with the employers to create an innovative program that involved new transit services and incentives for employees to use the service. Metro agreed to provide commuter express service from outlying park-and-ride lots to First Hill (not involving a transfer downtown) in exchange for guaranteed farebox recovery. The employers were asked to cover 80 percent of the operating cost of the express service. This was accomplished through the bulk sale of passes, whereby each employer had to purchase a set number of passes each month. Employers then provide the passes, good for all Metro bus service, to employees for free or at a highly subsidized rate. Most employers subsidize either 50 percent or 100% of the pass. Additionally, most employers allow transit users to park on-site one to two days per month and provide "taxi sweeper service" if employees miss the last bus or as a guaranteed ride home.

The utilization of the service is summarized in Table 3-3 as revealed in 1989 mode split figures for seven of the employers.

Swedish Hospital provides a good example of what impact this new service has had on one employer. Prior to initiation of the First Hill Express service in late 1988, Swedish charged employees $22 for parking, provided a substantial discount to carpools, and subsidized transit passes $15 per month. Realizing these incentives were inadequate, Swedish was instrumental in creating the First Hill Express partnership and raised their transit subsidy to 100%. Between 1988 and 1990, Swedish Hospital's drive alone rate dropped from 44 percent to 33 percent as the transit share increased from 31 percent to 44 percent, which translated into a 21 percent decrease in trips after the introduction of the 100% subsidy for all transit and the introduction of the First Hill Express. (*"Information Based on Survey Results from 1989,"* Snow, Kathy, Municipality of Metropolitan Seattle.)

Other Public Sector Incentives

- <u>Transit Fare Discounts</u>

  A considerable body of knowledge exists in the area of transit fare changes and traveler responses (see references). This section highlights examples of public transit operators that have provided direct or indirect discounts to travelers and therefore provided a financial incentive to use transit. As discussed in Section 3.1, public-sector provided fare discounts come in several forms and target both specific markets and all riders.

TABLE 3-3

Comparison of Mode Shares at First Hill Employers

Mode	Employer*							
	1	2	3	4	5	6	7	All
Drive Alone	55%	38%	62%	41%	44%	44%	51%	46%
Carpool	18%	13%	17%	16%	10%	14%	9%	14%
Vanpool	1%	3%	0%	4%	1%	1%	0%	2%
Regular Bus	15%	29%	11%	22%	30%	32%	28%	23%
First Hill Express	7%	4%	4%	4%	3%	3%	2%	5%
Bicycle/Walk	2%	4%	3%	5%	6%	4%	6%	4%
Other	2%	9%	3%	8%	6%	2%	5%	6%

* Key:

1 = Swedish Hospital
2 = Virginia Mason Hospital
3 = Providence Hospital
4 = Harborview Hospital
5 = Fred Hutchinson Cancer Research Center
6 = Puget Sound Blood Center
7 = Cabrini Hospital

- <u>Vanpool Start-up and Operating Subsidies</u>

  Another form of financial incentive provided to travelers involves start-up and operating incentives for commuters using vanpools. These incentives offer vanpool drivers and riders a direct subsidy and do not include state tax incentives to employers or vanpool owners for the capital cost of the vehicle. For example, some states, such as **California and Connecticut**, offer no- or low-interest loans to employers and vanpool drivers for the lease of vehicles. State tax credits, however, can directly benefit riders. For example, in **California**, vanpoolers are eligible for a state tax credit of 40 percent of their monthly fare, up to $480 per year.

Financial incentives provided directly to vanpool riders generally involve fare subsidies intended to induce new riders into vanpooling. The **Chicago Area Transportation Study (CATS) Rideshare** program offers vanpools (not individual riders) traveling to suburban job locations a $700 coupon book good for pro-rated fare subsidies for the first six months of existence ("*Urban Transportation Monitor*," published by Lawley Publications, Volume 5, No. 20, October 12, 1991). In **California**, the State Department of Transportation (CALTRANS) has an extensive vanpool support program tied to highway reconstruction mitigation programs. Commuters are generally offered a $100 incentive to try vanpooling (equal to one to two months' fare) and one corridor program (State Route 14) offers a $100 child care bonus. These programs are pervasive enough that 19 of the 35 vans serving the **Jet Propulsion Lab** in Pasadena qualify for new rider subsidies through the reconstruction program.

One unique example of a vanpool financial incentive program is that offered by the **Warner Center Transportation Management Organization (WCTMO)** in the Los Angeles area. The WCTMO receives funds from the city, derived from developer trip mitigation fees, to promote and subsidize vanpools. The incentives, implemented in 1989, include:

- Start-up fare subsidy for new riders (100% in first month, 50 percent in second and 25 percent in third);
- Equal subsidy for new drivers and partial subsidy for back-up drivers (which is actually a reward as drivers do not pay fares);
- Empty seat subsidy for occasional operating cost shortfalls;
- Loyal rider reward (12th month free after riding 11 months); and
- Recruitment reward (free month ride for recruiting new rider).

The vanpool subsidy program cost the WCTMO $235,000 in 1991, approximately 40 percent of its total budget. The vanpool mode share has almost doubled among member company employees, from 2.2 percent in 1987 to 4.1 percent in 1990, resulting from some 600 new vanpoolers.

3.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Assessing the impacts of employer- and public agency-provided financial incentives generally involves evaluating the effect that user subsidies have on mode choice. In other words, if financial incentives are aimed at changing the relative travel costs of alternatives to driving alone by offering direct subsidies, then the impacts should be measured in terms of these shifts. These impacts are expressed in different ways. Employer-provided financial incentives generate impacts expressed in terms of vehicle trips reduced as a result of user subsidies provided for commute alternatives. Public agency provided-financial incentives are most often expressed as the number of new carpoolers, vanpoolers or transit riders using these options. A more definitive measure, applied to changes in the price of travel options, is price elasticities. Price elasticies, with respect to demand, are expressed as the average change in usage or ridership in response to a unitary change in price. Each of these measures is utilized to describe the empirical evidence as to the impacts of financial incentives, as offered to travelers by employers and by public agencies.

3.5.1 Employer/Developer-Provided Incentives

The impact of employer-provided subsidies varies by the type and amount of financial incentive and by the existence of other supporting strategies. The examples provided above include the trip reduction or mode shift impacts of programs that include financial incentives as a principal strategy, including rideshare, transit and vanpool subsidies as well as travel allowances.

This section provides a summary of the impacts measured at the over 20 employer sites examined as part of this study. The impacts need to be divided into two primary categories; those programs with financial incentives alone and those with both financial incentives and parking disincentives (either limited parking supply or employee-paid parking).

Table 3-4 summarizes the impact of financial incentives at sites without parking disincentives. For each employer, the type and amount of subsidy is described and the resultant trip reduction cited. Trip reduction is expressed in terms of the proportional trip reduction resulting from the program as compared to similar control sites with no program or subsidies.

TABLE 3-4

Trip Reduction Impacts of Employer Subsidies

Employer	Subsidy/Incentive	% Solo	% Trip Reduction
Allergan	100% transit subsidy; 1-2 days vacation for R/S	82%	7.6%
Union Bank	100% transit subsidy	50%	15.0%
County of Ventura	$200 to $300 annual incentive	69%	11.5%
Varian	25% transit subsidy	57%	17.7%

Clearly, each of these programs includes aggressive promotion of commute alternatives and provides other incentives (awards, etc). Acknowledging the influence of these supporting elements and the influence of externalities, these four programs achieved an 8 to 18 percent reduction in trips by implementing financial incentives as part of a TDM program that *did not include the influences of limited parking supply or employee paid parking.*

As an interesting contrast, two downtown locations of the Bank of America in San Diego and Los Angeles were included in the examination of employer programs. Employees at these two bank locations paid the full cost of parking and the bank did not have a commute management program (although each now does). Faced with parking charges and no aggressive in-house TDM programs, less than half of the employees drove alone in contrast to 60 percent for each of the downtown averages. This resulted in a 12 percent reduction in trips among San Diego employees and an 18 percent reduction among Los Angeles workers.

Anecdotally, this suggests that rideshare subsidies and parking charges, when implemented alone, may have a similar range of impacts, resulting in a 10 to 20 percent reduction of trips. The four employers listed above realized an average trip reduction of 13 percent. When implemented together, however, the strategic pricing of modes that provides disincentives for solo drivers and incentives for users of commute alternatives can have an optimal impact. As described above, these programs can be implemented through one of three forms:

- *Rideshare subsidies and parking charges* implemented together;
- *Differential parking charges* based on occupancy; or

- *Uniform parking allowance*, used to "buy" any travel option and provide savings for lower cost alternatives.

Table 3-5 summarizes the trip reduction findings from those employers studied that provide some form of subsidy to ridesharers and where employees pay all or part of the cost of parking. The type of subsidy scheme listed corresponds to the three types enumerated above. Again, subsidy levels and parking charges vary, parking supply may be constrained, and most employers had comprehensive promotion and support programs. But the range of trip reduction results provides insights into the combined impacts of incentives and disincentives.

As can be seen from the table, the combination of rideshare and transit subsidies, parking charges and parking discounts for carpools and vanpools, resulted in a range of trip reduction impacts from 0.5 percent to 48 percent. The average reduction for the 14 employers is 23 percent.

Those with the greatest trip reductions (US West, the Nuclear Regulatory Commission (NRC) and Swedish Hospital) also experienced severe limitations on the amount of on-site parking available to employees. Thus, many employees could not even buy convenient parking if they so desired. On the other end of the spectrum, UCLA and the Los Angeles Department of Water and Power charge employees to park and provide parking discounts, but the parking rates are well below market rates, diminishing the ability to induce employees to shift modes. Both employers were charging $30 per month for employee parking when market rates in the area where commanding $150 to $200 per month.

When removing the sites with below market parking charges (lowest trip reduction) or extremely limited parking supply (highest trip reduction), the average trip reduction is 21 percent.

Overall Finding: **Based on over 20 employer-based TDM programs, evidence suggests that financial incentives for the use of commute alternatives are effective in reducing trips by 8-18 percent. Financial disincentives in the form of parking charges, when not supported by a TDM program, can also produce similar results. When financial incentives are combined with disincentives to driving alone (parking charges) the reductions can approach 50 percent.**

Table 3-5

Trip Reduction Impacts of Employer Subsidies and Parking Charges

Employer	Type of Subsidy	% Solo Driver	% Trip Reduction
Travelers (CT)	Parking discount Transit subsidy	33%	25.4%
Hartford Steam	Parking discount Vanpool subsidy Transit subsidy	40%	13.6%
NRC (MD)	Transit subsidy	42%	41.6%
US West (WA)	Parking discount	26%	47.6%
Puget Power (WA)	Transit subsidy	77%	12.6%
CH2M Hill (WA)	Travel allowance Transit subsidy	54%	31.2%
ARCO (CA)	Parking discount Rideshare subsidy Transit subsidy	40%	19.1%
UCLA (CA)	Parking discount	74%	5.4%
LADWP (CA)	Parking discount	55%	0.4%
Bellevue City Hall (WA)	Parking discount Rideshare subsidy Transit subsidy	52%	25.8%
Pasadena City Hall (CA)	Parking discount Rideshare subsidy Transit subsidy	58%	16%
San Diego Trust & Savings (CA)	Travel allowance Transit subsidy	44%	23%
Swedish Hospital (WA)	Parking discount Transit subsidy Vanpool subsidy	33%	40.7%
Transamerica (CA)	Parking discount Transit subsidy	45%	19.9%

3.5.2 Public Agency Sponsored Incentives

As mentioned above, the impact of public agency-sponsored incentives, which directly and indirectly provide subsidies to travelers, is generally expressed as the number of riders induced to use a desired alternative. Impacts from transit fare reductions and vanpool subsidies, which are available directly to the user, are revealed in increased ridership on transit and new vanpools and vanpool riders. Impacts from transit subsidy and prepayment schemes, which are channeled through employers, are revealed through the trip reduction results of the employer's overall program and through increased ridership on public transit.

- Impact of Transit Subsidy Matching Programs

  Two examples of transit subsidy matching programs were cited above. The Fare Share program in Montgomery County, MD sold monthly transit passes to area employers at a 25 percent discount as long as employers matched the subsidy and sold passes to employees for 50 percent of their face value. In 1990, the last full year for the program, over 2,300 commuters participated in the program in almost 100 firms. Of these participants, **1,300 were said to be new transit riders and the program estimated to remove over 1,800 vehicle trips per day.**

  In the case of the First Hill Express in Seattle, the introduction of the new direct transit service, backed by employer pass purchases and subsidization for employees, resulted in significant shifts to transit. According to a 1989 survey, 5 percent of all First Hill employees were using express service and 23 percent using regular METRO bus service. Looking at one employer, Swedish Hospital, the introduction of the First Hill Express was a major factor in increasing their transit share from 31 percent to 44 percent. While the shift to transit was evident (carpooling and vanpooling changed very little), other employer program elements contributed to the impacts (parking supply was restricted and fees increased). The increase in transit usage at Swedish Hospital, prompted by both the new service and parking controls, **lead to a 21 percent reduction in trips.**

- Transit Fare Prepayment Discounts

  Generally provided through employers, transit passes at a discounted rate (over the full fare price) can produce increased ridership and reduced fare collection costs, and this often outweighs the revenue lost from discounting fares. **Prepayment, in conjunction with employer subsidization, has been shown to be quite effective in reducing trips**, as discussed above. However, the impacts of prepayment alone are most often revealed in program participation rates and the number of new transit riders. One demonstration in Jacksonville, Florida enrolled 30 employers into a discounted pass program and increased sales from 120 to over 1,000. One-third of the employers were subsidizing the passes and about 20 percent of all participants were diverted from automobile commuting. About 20 percent of the employees in three firms that offered additional subsidies commuted by transit as compared to 4.5 percent among employees who just received the pass discount. Likewise, in Sacramento, a 14 percent discount in the price of a pass (over full fare, pay-as-you-go) resulted in a four-fold increase in pass sales. In Austin and Phoenix, 20 percent and 40 percent discounts lead to significant increases in sales, but new ridership overall, attributable to the pass discount, was less than 0.5 percent. Other research suggests that while the short-term ridership gains can be significant, long-term patronage increases are less common. Thus, prepayment discounts, evaluated on their own do not seem to have a lasting impact on transit ridership. ("*Traveler Response to Transportation System Changes, 2nd Ed.,*" Pratt, Richard H.; Copple, John N., Barton-Aschman Associates, Inc., R.H. Division for the U.S. Department of Transportation, FHWA, July 1981).

- Fare Reductions

One means to directly provide a subsidy to users is to reduce the price of travel alternatives to the automobile. Transit fare reductions are generally not targeted to commuters, but rather to other markets (off-peak, seniors, etc.) or system-wide. In fact, commuter express service is provided at a fare premium. Additionally, fare reductions are fairly rare in an age of fiscal constraints. As noted above, Austin, Texas just switched back from a free-fare system. The reason for the uncommon use of fare reductions for commuters and others as a demand management strategy is that **transit demand is generally price inelastic**. This means that a change in fare does not result in a proportional change in ridership. The elasticity of fare reductions averages about -0.37. This means that a given decrease in fare results in only one-third as much increase in ridership or a 10 percent reduction in fare results in a 3.7 percent increase in ridership. When considering fare elasticities for various markets, it is clear that peak period travelers, workers and higher income travelers are less price sensitive than others. Average fare elasticies for these markets range from -0.10 to -0.19 as compared to -0.28 for all travelers. One interesting finding concerns the provision of free transit service within a downtown area. When an existing fare (often a dime) was eliminated for a downtown circulator bus, the average fare elasticity was -0.52, resulting in a 5 percent increase in ridership for every 10 percent decrease in fare.

- <u>Vanpool Subsidies</u>

  Direct subsidies from public agencies to commuters to defray vanpool fares are becoming more widespread, but the evidence of overall impacts is limited. Perhaps more common are state programs that provide low- or no-cost loans for vanpool acquisition or allow vanpoolers to receive tax credits or deductions for fares or capital expenditures. The subsidy programs have had varied success in forming new vanpools, but their impact on congestion levels in targeted corridors or employment centers is unclear. Most of the subsidy programs are focused on specific corridors (under reconstruction) or activity centers for congestion relief.

  The number of new vanpools formed is often the only results-oriented findings. The Montgomery County vanpool subsidy reports the formation of 22 vans over the three-year life of the program. The Jet Propulsion Lab in Pasadena reports that **a jump in vanpool formation** (from 4 to 26 vans in one year) **was largely attributable to state-provided start-up subsidies and tax credits.**

The Warner Center Transportation Management Organization (WCTMO) receives developer impact fees funds from the City of Los Angeles and uses the funds to promote and subsidize vanpool start-ups. In 1991, the WCTMO had recruited a total of over 1,400 new vanpoolers and 41 new vans (as compared to some 35 vans serving the center prior to 1988). Warner Center employees were either placed into existing employer vans or groups were formed into "multi-employer" vans. **The ability to form these cross-company vans is a significant result of the subsidy and the TMO's role.** As a result of the WCTMO's vanpool program, the vanpool share among participating employers rose from 2.2 percent to 4.1 percent, as compared to 0.1 percent region-wide.

Overall Finding: **Transit fare prepayment discounts and fare reductions, when analyzed alone, do not seem to have a significant impact on transit usage. When combined with employer subsidies, discounts and fare reductions can contribute to more substantive results. Vanpool subsidies serve to form new vanpools in response to corridor and activity center trip reduction efforts.**

3.6 COST EFFECTIVENESS

Given that the objective of most TDM programs is trip reduction, be it for congestion relief, air quality improvement or site access, the primary cost effectiveness measure is cost per trip reduced. In lieu of that, the cost per traveler placed into transit or a commute alternative is perhaps a useful surrogate. In the case of employer and developer programs, the cost per person placed is derived from the case studies performed as part of this report. Additionally, the total amount of the subsidy program and proportion of program budget is reported. In the case of public agency provided incentives, the cost effectiveness data is only available for total costs or the cost per new rider. Finally, in the case of fare reduction and prepayment discounts, the impact on operating costs and revenue is often estimated.

- Employer Program Cost Effectiveness

  As reported in the carpool section (Section II A.2), the average cost per daily trip reduced among 12 employers examined was $1.31. This was calculated by dividing the total program costs by the number of trips reduced as a result of the program. When compared to the public sector costs of accommodating those trips on new highways or transit service ($6.75 and $4.10, respectively), employer based programs appear to be very cost effective in reducing trips *(Part III, Effective Travel Demand Actions,* COMSIS/FHWA, 1992).

  These figures, however, mask the differences between programs that combine subsidies (incentives) with parking controls (disincentives). Table 3-6 compares costs for the employer programs cited in the examples.

  The table reveals a greater variation in the daily cost per trip reduced and the proportion of program costs dedicated to the subsidies themselves. However, Allergan's program includes a vanpool acquisition fund which is only partially off-set by vanpool fares. The County of Ventura and Varian are more representative of subsidy-only programs and reflect the cost to provide an annual cash incentive (Ventura) and transit pass subsidy (Varian) which are at the heart of each program.

TABLE 3-6

Program Costs for Incentive-Based Employer Programs

Employer	Annual Budget	Amount of Subsidy (% of Total)	Net Cost per Trip Reduced
Allergan	$239,950	27%	$9.98
Union Bank	Insufficient Data	N/A	N/A
County of Ventura	$223,500	76%	$2.63
Varian	$102,000	33%	$0.80

When examining employer programs that include subsidies, differential parking charges and other parking controls, the range of cost effectiveness is also quite varied, from a cost per trip reduced of $0.24 to $13.52. Programs with low trip reduction costs (US West and the Nuclear Regulatory Commission) involve differential parking rates for SOVs and HOVs and low administrative costs. This coupled with a significant reduction of trips (47 percent and 41 percent) contributed to low unit costs to reduce each trip. Other programs, such as UCLA and the City of Pasadena, experience high unit costs for trip reduction, $11.24 and $13.52, respectively. In these cases, lower trip reduction success (5.4 percent and 16 percent), high administrative costs, and a broad range of subsidies and promotions contribute to high unit costs for each trip reduced. This confirms the overall effectiveness of parking pricing as a TDM strategy.

However, of greatest interest is the ability of these programs to reduce the unit cost of reducing a trip or **realize a net cost savings** by generating parking revenue from the program or avoiding the cost of building or leasing more parking. The City of Bellevue provides a good example of the cost effectiveness of subsidy programs tied to parking charges. Exclusive of administrative costs (less than $50,000 per year), the City provided $52,000 in ridesharing and transit subsidies in 1990. Parking charges generated $105,000, and **the program paid for itself by realizing parking revenue equal to the cost of the subsidies and program administration.** For the examples cited above, the net savings per trip reduced (cost minus parking revenue or savings) for US West is $0.75 and for NRC is $5.28, based on avoiding parking construction and revenue from parking charges. In the case of UCLA, the net cost of the program is $4.99 (operating costs minus avoided parking costs) and for the City of Pasadena, the net cost is $7.02. Thus, parking savings on the order of $5.00 per trip reduced contribute to the cost effectiveness of employer-based TDM programs by either generating a net savings or reducing the unit cost for more comprehensive programs. In fact, two programs, Travelers Insurance and Swedish Hospital realize *a net savings* of almost $7.00 per trip reduced tied to parking savings.

Subsidies are often the largest budget item in an employer-based TDM program. Table 3-6 showed the annual subsidies and budgets for several of the employer programs explored, ranging from 27 percent to 76 percent. Three other programs, Bellevue City Hall, Warner Center TMO and San Diego Trust and Savings spend 50 percent, 72 percent and 50 percent of their annual budgets, respectively, on subsidies. Therefore, most programs that emphasize subsidies spend approximately half of their budget on financial incentives and less than half on administration. Only one program listed above realizes parking revenue (Bellevue), and, therefore, these employers are incurring significant costs ($33,000 - $424,000 per year) to subsidize alternative commute modes. However, subsidies, especially when combined with parking controls, have proven to be very effective means to reduce trips by shifting employees into non-SOV modes.

- Public Agency-Provided Incentives

  Information on the cost effectiveness of public agency-provided incentives, subsidies and discounts is generally not reported in terms of cost per trip reduced. Overall program budgets are reported and the number of passes sold or vanpools formed cited. However, the Montgomery County Fare Share program and vanpool subsidies can be transformed into annual costs. The transit subsidy cost the County $265,000 in 1990 and subsidized the rides of 2,300 transit users. Of this, 1,300 were new transit riders, diverted from driving alone and ridesharing. This equates to an annual cost per new rider of $203. This does not include the subsidies matched by employers. An annual cost of just over $200 compares favorably to some of the employer examples cited above. The annual subsidy per rideshare participant at Bellevue City Hall is $191 ($51,000/272 participants).

  The Montgomery County vanpool subsidy of $2,100 per new vanpool equates to an annual subsidy per vanpooler of $175. Programs in California, tied to highway reconstruction, generally subsidize commuters a total of $100 for getting into a vanpool. Finally, in Warner Center, developer fees, to be used for TSM improvements, are used for vanpool subsidies. The City of Los Angeles' criteria for allowing impact fees to be used for TDM (as opposed to capital improvements) was an assessment that the TDM techniques must be as effective as computerized signal coordination techniques. While a specific analysis was never performed, vanpool subsidies were viewed as an effective alternative or enhancement to more traditional TSM improvements.

  While the programs have been effective in forming new vanpools, the cost effectiveness of providing start-up operating subsidies, versus vehicle acquisition loans or broader commute alternatives subsidies or programs, is unclear. Finally, cost effectiveness data for transit prepayment and fare discounts is limited. The relatively small proportion of new transit users induced by the discounts and the revenue neutral nature of pass prepayment schemes makes cost effectiveness analysis problematic. Suffice it to say that these pass prepayment discounts, when combined with employer subsidies, can contribute to significant trip reductions, with little or no net cost to the public transit provider.

Overall Finding: **Employer programs that offer financial incentives and those that combine subsidies with parking controls exhibit a broad range of costs, from $0.24 to $13.52 per daily trip reduced. However,**

parking revenue and capital costs foregone can greatly reduce the cost per trip reduced, cross-subsidize financial incentives, or even realize a net cost savings. Public agency subsidies and transit discounts are likely most cost effective when combined with employer participation in financial matching programs.

3.7 IMPLEMENTATION ISSUES

The provision of direct subsidies to users of travel alternatives is not widespread among employer and public agency TDM programs. Most programs attempt to induce mode shifts by providing travelers with improved information on alternatives. However, information alone cannot counterbalance the overwhelming cost, and time savings and convenience associated with driving alone. Even the potential sharing of operating costs available from carpooling is not enough to sway most travelers. Thus, the ability to provide incentives to using alternatives (or disincentives to driving alone), are among the most effective means to realize trip reduction objectives.

While few if any existing regulations require financial incentives be offered as part of employer trip reduction programs, TDM plans are being rejected for a lack of such incentives and public sector subsidies are provided on a matching basis with employer subsidies. Such public policy trends are based on a growing realization that employer-provided financial incentives are perhaps the most effective and acceptable (emphasizing "carrots" instead of sticks") strategy for reducing trips.

In implementing public sector subsidy and fare discount programs, the primary issues revolve around the role of the subsidies in an overall TDM policy or program and the ability to link public subsidies to employer programs that involve a matching subsidy. Specifically, implementation issues to be considered include:

- The ability of subsidies to fulfill **public policy objectives** in an effective, equitable and consistent fashion;
- The relationship of user subsidies to employer and developer **requirements** in terms of strategic reinforcement of employer programs;
- The use of **impact fees, transportation funds or general funds** to provide subsidies rather than or in addition to new services and infrastructure;
- The ability of employer transit pass program to **increase ridership and offset revenue loss** from prepayment discounts; and

- The desirability of reducing transit fares for specific markets given the price inelasticity of transit fares with respect to demand.

Perhaps the most effective scheme for providing user subsidies and transit discounts is to provide financial incentives to employers, rather than directly to travelers, so as to reinforce in-house trip reduction programs and assist in compliance with requirements. Tying subsidies to an employer-match benefits travelers, employers and the public agencies by maximizing the subsidy available to travelers. Revenue for public subsidies can come from a variety of sources. User fees, such as parking revenue or taxes, can be utilized. Business taxes and developer fees can also be utilized.

Employer consideration of financial incentives include issues related to employee benefits and equity. In general, most employers implement subsidies when their information-based program does not yield required or desired results. Alternatively, where parking supply is limited at a site to which the employer is relocating, financial incentives are provided to reduce parking demand and provide relocation assistance to employees. Specifically, implementation issues include:

- The provision of a subsidy for ridesharers versus a travel allowance for all employees and related equity issues;

- The inclusion of commute benefits in the firm's overall benefits package and the inclusion of commute benefits in the collective bargaining process;

- Federal tax law currently requires all commute benefits (except transit subsidies up to $21) to be treated as taxable income to the employee;

- Subsidy programs and related tax reporting require administrative support beyond the promotion of alternatives;

- The ability of parking charges and vanpool fares to offset significant subsidy expenses; and

- The disposition of extra parking due to reduced parking demand.

As mentioned above, subsidies are most effective when combined with parking charges. Therefore, the most effective means for implementing subsidies may be the provision of a travel allowance giving employees the opportunity to make monthly choices between parking and commute alternatives based on personal needs and potential cost savings. The net cost to the employer under an allowance scheme is the amount of subsidies retained by ridesharers. However, parking charges, differential rates based on occupancy, and rideshare subsidies can be combined to produce intended effects. Rather than subsidizing all travelers, parking fees charged of solo drivers directly cross-subsidize users of commute alternatives, as is the case with Bellevue City Hall. The decision to use a travel allowance versus a cross-subsidization scheme will depend on a variety of equity, administrative, policy and financial issues. However, the ability of subsidies, when combined with parking charges, to produce the most effective programs examined to date, suggests that the inclusion of financial incentives in TDM programs as a primary strategy be a top consideration when developing an effective program.

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B.4 PARKING SUPPLY AND PRICING MANAGEMENT

4.1 DESCRIPTION OF STRATEGY

LOCAL PARKING POLICY

The development and management of parking supply involves many public and private sector groups. The public sector plays several roles in parking:

- Localities set "parking requirements" in codes. The requirements oblige developers to provide a certain amount of parking with their developments. Requirements in zoning codes usually vary with the type of land use. For example, office developments might be required to provide three or four parking spaces per 1,000 square feet of development. Industrial, retail and other uses will have different requirements.

- Some localities build and manage off-street parking supply, whether to encourage shopping or as part of redevelopment, or generally to control the location and price of parking. The off-street supply might be surface lots or garages.

- Localities control the supply and regulation of on-street parking. On-street controls discourage commuters from parking in neighborhoods ("preferential parking programs"), or encourage turnover in shopping areas (meters and timed zones).

- Finally, localities influence the revenues and rates charged by private providers of parking, if and when they impose revenue or space taxes on private providers.

The Federal government also influences parking policy. The IRS exempts from taxes free or subsidized parking offered by employers to employees. The result is more employee demand for parking, higher local parking requirements and less incentive for use of transit and ridesharing compared to the case where subsidized parking is taxed.

The private sector also has an important role in parking. Where the market allows, commercial parking operators provide and price surface lots and garages available to commuters and shoppers. Developers provide parking as part of commercial developments. At office developments, these developers lease some parking to project tenants and some to visitors. At retail shopping centers, all or most of the parking may be open to the public at large.

Policy changes influencing parking supply, price and location do not come easily, in part because any change raises equity issues across affected parties. For example, a change in how much parking government code allows and where it is allowed influences the cost and revenues of parking, as well as market viability of an entire development. Such a change applied to new developments favors or disadvantages developments already in place, depending on whether new requirements allow more or less parking. Supply or pricing changes at an activity center, whether downtown or suburban, may favor or disadvantage activity center growth and the economy relative to other centers in a region. Parking policy changes pertaining to commuters may well influence parking availability for visitors and shoppers. Revenues of the commercial parking industry are affected by changes in parking taxes, code-required supply and location.

PARKING AND DEMAND MANAGEMENT

Parking is a vital element of any Transportation Demand Management program. Considerable recent and past research suggests the supply and price of parking may be the most potent demand management strategy. For example, one recent study found parking pricing alone was as effective in reducing trips as a combination of several demand management strategies implemented without parking pricing ("*Parking Cost and Mode Choices Among Downtown Workers: A Case Study*," Maria Mehranian, Martin Wachs, Donald Shoup, Richard Platkin, Aug. 13, 1986). Because parking pricing is so central to traveler choices between solo driving, carpooling, transit use, and walking, traffic congestion and air quality are intimately linked to parking. Therefore, planners and decision makers should examine parking policy as part of their demand management programs to maximize effectiveness.

Localities can integrate parking into their demand management efforts through two broad approaches: pricing and supply management.

PRICING

Governments may take several approaches to pricing parking. They may:

- Impose or increase fees and surcharges for solo drivers or long-term parkers in public parking facilities;
- Give price preference to carpools and vanpools;
- Tax the providers of parking, whether commercial operators of parking or all public and private entities providing parking;

- Impose parking pricing through regional regulations, for example air quality regulations or special legislation; and

- Especially regarding state government, tie funding allocations for road improvements to requirements for local trip reduction plans incorporating parking pricing among other demand management strategies.

Developers, employers and Transportation Management Associations also can play a role in pricing. One or more of these entities can:

- Remove, reduce or cash out employer-provided parking subsidies;

- Reverse "early bird" or monthly discounts favoring long-term commuter parking;

- With or without government regulation, impose parking pricing and discount parking for carpoolers where free parking prevails, or where carpoolers enjoy no price breaks; and

- Develop parking regulations and pricing for commercial and retail mixed-use areas and manage and enforce parking.

Some examples include:

- Madison, Wisconsin, imposes a peak period surcharge at municipal garages to encourage commuters to switch to shuttle service;

- Seattle discounts carpool parking downtown and requires the same discounts in many development agreements;

- San Francisco increased rates at public and commercial garages through a parking tax as part of its "transit first" policy. Through developer agreements, the City also negotiates parking rates at new commercial developments;

- Employers in Bellevue, Washington, Los Angeles, California and Montgomery County, Maryland have imposed parking pricing on employees alone or in combination with travel allowances, or provided effective parking subsidies to rideshare patrons;

- Montgomery County, Maryland ended its sale of discount monthly parking booklets for commuters; and

- The Transportation Management Association in Bellevue, Washington for some time managed and enforced parking to prevent commuters from parking in shopper areas.

SUPPLY MANAGEMENT

Localities influence the supply of parking at and around developments through:

- Parking code measures;
- On-street controls (meters, timed zones, neighborhood preferential parking); and
- Controls on the amount of parking built and operated by the public sector.

Localities can exert the most direct control over parking supplies through the zoning code. Parking codes establishing the amount of parking developers must provide ("minimum" required) can be set with low minimums and/or maximums ("maximum" which can be provided) to insure overly ample supplies are not provided. Or, localities can allow reductions in minimum requirements ("flexible" requirements) in return for traffic mitigation. Developers can reduce the minimum amount of parking required in return for supporting transit, carpooling, cycling and other alternatives to solo driving. Examples include:

- Portland, Oregon sets a "lid" on the total supply of parking, except hotel and residential parking;
- Seattle and Bellevue, Washington put limits (a "maximum") on the amount of parking at commercial developments. The limit is tied closely to transit in the case of Seattle;
- San Francisco limits parking to seven percent of gross floor area in commercial developments within the downtown area where transit service is good;
- The City of Hartford, Connecticut, requires all new parking downtown to be underground, partially to encourage development of off-site parking. The city also reduces minimum required parking in return for developer carpool and transit encouragements;
- Similar reductions in minimums are found in Palo Alto and Sacramento, California, and in Chicago, Illinois; and

- Calgary, Canada, and Orlando, Florida, have required or allowed payments "in-lieu" of on-site parking. Fees support municipal parking, whether central or peripheral to downtown.

4.2 NATURE OF EFFECTIVENESS

PRICING

The effectiveness of parking pricing in reducing solo driving and increasing use of alternative modes of travel depends on several factors, including:

- The level of price and the share of cost actually borne by the traveler; and

- The attractiveness of travel and parking alternatives.

Looking at the first issue, obviously the higher the price charged for parking, the greater the effect in causing the solo driver to consider alternatives. And higher starting price levels may also produce greater shifts with additional price increases than initially low levels ("*Employer Paid Parking: The Problem and Proposed Solutions for the Association for Commuter Transportation,*" Richard Wilson and Donald Shoup, December 1990).

Equally important is the share of the parking charge that is passed on to the traveler. Pricing measures will have understandably less effect if travelers are shielded from the costs, in whole or part, by employer subsidies or similar intervention. The proportion of commuters with employers paying for all or part of parking may be over 50% in some areas ("*The Effect of Employer Paid Parking in Downtown Los Angeles for Sacramento County Association of Governments,*" Richard Wilson and Donald Shoup, May 1990).

With regard to the attractiveness of alternatives at least two factors are important to the effect of pricing:

- Availability of transit and other alternatives to solo driving; and

- Availability of uncontrolled parking .

Generally, pricing can be expected to be the most effective in shifting commuters to alternative modes where the quality of those modes is higher. This is generally reflected in prior rates of use of alternatives that is favorable; so, in other words, if pricing (initial or surcharges) is introduced in a setting where modal shares of transit or ridesharing are higher than another setting, those pricing changes will produce a higher impact. Also, much of the effectiveness of parking pricing (or space) management depends on the availability and pricing of adjacent parking opportunities. These include neighborhood streets, adjacent commercial lots, vacant lots, and even utility and train rights-of-way. Obviously, these conflicting opportunities must be managed if parking prices are to have their intended impact.

SUPPLY MANAGEMENT

The supply of parking is an important determinant underlying commuter choice of travel mode. Generally, the tighter the parking supply, the more likely drivers will consider using alternative modes. The relevant "supply" includes all available parking to commuters, both on and off-site within walking distance. Evidence for the importance of parking supply comes from two recent studies:

- One review of demand management programs in Seattle found both price and availability of parking were important determinants to the proportion of solo drivers. However, comparing buildings with relatively high parking prices and good transit service, but differing in terms of the availability of parking, the study found the most solo driving where parking was ample ("*The 1987 Evaluation of Transportation Management Programs, Final Report*," Mike Lent and Elizabeth Rankin, Seattle Commuter Services, 1987).

- Likewise, a recent study of parking and transit use at San Francisco hospitals found parking price the single most important determinant, "accounting for up to 80 percent of the variation in mode splits among six institutions." However, the availability of off-site parking and nearby transit service were next most important in determining the degree of employee auto use ("*Factors Affecting TDM Programs' Effectiveness at Six San Francisco Institutions*," Dr. Richard Dowling, Dowling Associates, Paper before the 70th annual meeting of the Transportation Research Board, January, 1991).

Localities with the best prospects for realizing reductions in solo driving through parking supply restraints are where some or all of the following conditions apply:

- Developer and lender preferences or minimum parking codes result in more parking than is utilized. In such settings, minimums might be lowered if they are the cause of overly ample supplies. Or, maximums might be imposed to prevent developers and lenders from creating excessive supplies.

- Mixed uses are available or planned where parking supplies can be shared. In this setting, localities can negotiate for parking supplies serving several compatible uses instead of separate and more extensive supplies serving each use.

- Commercial and public parking is well utilized, thereby limiting opportunities for parkers to simply shift parking locations as supplies are tightened.
- The costs of providing parking are high compared to traffic mitigation alternatives. In such settings, developers and lenders may be more willing to reduce supplies.
- Transit capacity is frequent and not saturated, offering a good alternative for drivers affected by tightened supplies.
- Uncontrolled supplies (streets, vacant land, neighborhoods) are at a minimum or new controls are planned.

4.3 APPLICATION SETTING

PRICING

Pricing can be applied to:

- Individual developments and employers;
- Entire employment centers in urban or suburban settings;
- Public facilities, typically in downtown areas;
- Public parking districts in urban or suburban settings;
- Commercial parking through rate regulation or parking taxes; and
- Regions through air quality or funding allocations legislation.

In each case, pricing can be effective in reducing vehicle trips, depending on local objectives. For example, in a downtown or suburban setting where the public sector controls a considerable amount of parking, pricing policies may be effective in reducing both local and regional trip making. However, in localities where private parking dominates, changes in public parking pricing may reduce local trips to and from public facilities, but have little effect over the locality taken as a whole. In such settings, parking policies must address the commercial and private sector. National surveys show private off-street parking makes up from 15 to 60 percent of all off-street parking depending on the locality. Thus, the focus on public versus private and commercial parking will vary from locality to locality.

Another important consideration is the proportion of through traffic and the importance of reducing it. In urban downtowns, through trips make up anywhere from 30 to 60 percent of automobile trips, though the total is 15 to 30 percent for downtown areas taken as a whole ("*Parking Taxes for Congestion Relief: A Survey of Related Experience*," Damian Kulash, Urban Institute, 1974). For localities aiming to reduce both local and through trips, pricing strategies will have to be coordinated across jurisdictions.

The best candidate localities for pricing strategies are those where some amount of parking pricing already is in place. It may be more difficult (but not impossible) to impose prices if public or private parking are currently free. An excellent candidate application setting might be public garages where rates have fallen behind commercial parking rates, and where these rates offer no differentials for carpoolers. Governments in these settings might consider raising rates for solo drivers, providing discounts for poolers and graduating rates by peak versus off-peak arrival, or long- versus short-term parking. Ending any discounts for patrons buying monthly tickets also provides another opportunity. Of course, these strategies are the most applicable where:

- The public supply makes up a substantial proportion of the total parking supply;
- There are few opportunities for spillover parking (into retail or neighborhood areas with no pricing or parking regulation); or
- Transit into the priced zone has some capacity or will be improved.

Two other opportunities are important to consider. One is where commercial rates encourage long-term parking by "early bird specials" or monthly discount parking compared to daily rates. These polices might be reversed through regulation or negotiation with the commercial parking industry. Another opportunity exists where employers provide parking subsidies to employees. Localities might require employers subsidizing employee parking to offer a cash travel allowance or salary hike as an option. For example, suppose an employer pays for the parking of its company managers. Under this option, the employer would have to offer managers the option of taking the cash equivalent ("cash out") of the subsidy instead of receiving subsidized parking.

The rationale for the cash out is some employees will prefer to "pocket" the cash and take transit or carpools to work. One study of Los Angeles commuters estimates the cash out might reduce solo driving by as much as 24 percent ("*The Effects of Employer Paid Parking in Downtown Los Angeles*," Richard Wilson and Donald Shoup, UCLA School of Architecture and Urban Planning, May 1990). The implementation section of the paper provides some specific suggestions for addressing commercial rates and employer subsidized parking.

SUPPLY MANAGEMENT

The best candidate localities for supply strategies may be suburban communities. Supplies in these communities tend to exceed demand. Surveys of suburban office parks show supplies between 3.5 and 4.0 spaces per 1,000 square feet of floor space, and surveys of usage in California and Texas found office workers only required about 2.2 spaces per 1,000 square feet (*"America's Suburban Centers, A Study of the Land Use-Transportation Link,"* Dr. Robert Cervero, University of California at Berkeley, January, 1988). These same communities may also be sites for new mixed-use developments where parking can be shared across uses.

Urban communities may be opportunities for other strategies. Here, the high cost of parking may encourage developers to seek reduced parking in return for traffic mitigation strategies. Or, if parking subsides are to be reduced or matched by transit subsidies (as required by recent legislation in Los Angeles), parking requirements might be reduced to be more in line with new anticipated parking demand. Finally, parking requirements may be reduced in proximity to transit stations where employee transit use may well reduce parking demand.

4.4 EXAMPLES

PRICING

There are several documented cases of dramatic declines in solo driving and trip making resulting from employers imposing parking pricing, or removing employee parking subsidies, whether alone or in combination with alternative mode programs. Examples span suburban, urban and downtown areas.

In suburban settings, both public and private employers have reduced solo driving through a combination of pricing strategies and alternative mode programs such as carpool and transit encouragements. Cases summarized in the literature (COMSIS, K.T. Analytics, Inc.) illustrate the possible range of effects:

- Nuclear Regulatory Commission, 12 percent reduction in solo driving compared to before pricing (though the 42 percent solo share is about 40 percent below solo shares of other employers in the area);
- Bellevue City Hall, 17 percent compared to before pricing;

- CH_2MHill, 25 percent compared to before pricing;

- Twentieth Century Corporation, 25 percent decline; and

- Pacific Northwest Bell, 40 percent lesser proportion of solo drivers compared to other employers in the area.

In an urban but not downtown setting, Commuter Computer outside the Los Angeles central business district dropped the drive alone share from 42 percent to 8 percent by eliminating free parking (Monica Surber, Donald Shoup, Martin Wachs, *"The Effects of Ending Employer-Paid Parking for Solo Drivers,"* University of California, Los Angeles, California, 1984).

In urban settings, parking pricing again has been effective. However, several of the cases suggest certain cautions in designing pricing programs:

- ***City of Madison:*** The City imposed a peak period surcharge of $1.00 at four parking facilities combined with new shuttle service. Five to eight percent of commuters switched to transit. However, 22 percent shifted parking location, and six percent parked after the peak (Charles River Associates, *"Madison Peak Period Parking Pricing Demonstration,"* USDOT, 1984). The Madison case underscores the possibility that some commuters will shift parking locations or time of parking rather than mode of travel, at least under surcharges.

- ***City of Seattle:*** The City reduced parking charges for car-pools at two Seattle parking facilities downtown, from $25 to $5 per month at one facility and $0 at another. Twenty-five percent of the participants in the program were previous solo drivers, suggesting considerable trip reduction. However, some participants were previous transit users (45 percent) and carpoolers (29 percent), suggesting the importance of monitoring the effects of pricing programs on all modes of travel (Marie Olsson and Gerald Miller, *"Parking Discounts and Carpool Formation in Seattle,"* The Urban Institute, 1978).

- ***City of San Francisco:*** The City increased rates at public (and commercial) facilities through a 25 percent tax and found large variation in the decline of vehicles parked at the facilities. The number of parked cars declined at seven facilities but increased at six others. Overall, the number of parked cars declined about two percent, but it is not known what proportion of parkers turned to transit, carpooling or other alternatives to auto use. The lesson appears to be that fairly substantial increases in parking taxes may be needed to reduce parking demand, and the effects will vary depending on location (*"Parking Taxes as Roadway Prices: A Case Study of the San Francisco Experience,"* Damian Kulash, Urban Institutes, 1974).

- ***U.S. Federal Government:*** The Federal Government charged employees for parking at selected federal facilities, reversing a previous policy of free parking. Rates were changed from mostly free to one-half the rates at nearby commercial lots. The reduction in the number of autos commuting ranged from one to 10 percent in central city areas, and between two and four percent in suburban locations (*"Raising Commuter Parking Prices - An Empirical Study,"* Gerald Miller, Carol Everett, Transportation, Volume 11, 1982).

- ***Federal Government of Ottawa:*** The Federal Government began charging near market price for employee parking in Ottawa. Solo driving decreased by 21 percent (from 35 percent to 28 percent), with large shifts to transit even among higher income employees. Overall, about seven percent of workers changed mode of travel (*"Implementing Parking Pricing Strategies,"* Gerald Miller and Thomas Higgins, Urban Institute, 1983).

- ***City of Chicago:*** The City raised rates from 30 to 120 percent, bringing fees up to levels at nearby commercial space. The number of parked cars declined 35 percent and parking duration decreased. The number of all-day-parkers arriving before 9:30 a.m. dropped 72 percent. Local planners inferred most former long-term parkers switched to transit, pooling or parking for shorter durations. However, no hard evidence was gathered on mode shifts. Parking at nearby commercial parking facilities did not change significantly. Revenues from municipal facilities increased (*"Impacts of Municipal Parking Fee Increases in Downtown Chicago,"* R.C. Kunze, et. al., Paper before the 59th Annual Meeting of the TRB. Also, Miller and Higgins, op. cit.). The important lesson from this case is the potential that pricing has to not only reduce long-term parking and influence mode of travel, but to increase parking revenues at public facilities.

- ***City of Eugene, OR:*** Raised rates at two municipal garages and several surface lots. Rates at garages went from $16 to $30 over about one year. Surface lot rates went up from between $6-16 to $16-34. Meter rates did not change, but fines were increased for commuter parking in short term stalls for shoppers. Monthly parking permit sales declined from 560 to 360 parkers. About half the parkers became carpoolers or rode a free shuttle, the other half apparently changed parking locations (*"West University Neighborhood Parking Pricing Demonstration Program in Eugene, Oregon,"* Peat, Marwick, Mitchell and Co., Final Report, July 1985). The Eugene program demonstrates the potential for pricing to shift where parking takes place, and the need for enforcement strategies to accompany pricing.

SUPPLY MANAGEMENT

Parking supply strategies also have exhibited success in trip reduction through increased transit use and reduced solo driving. Two examples illustrate the execution of parking code supply management strategies, and results associated with the strategies:

- ***Portland, OR:*** The parking code sets a maximum number of parking spaces allowed depending on proximity to transit, with no minimum except for residential uses. Requirements in most areas are one space per 1,000 square feet of development, but ranges to a low of 0.7 spaces per 1,000 square feet. The City is generally satisfied with its parking policies and believes it has helped maintain high transit usage. As many as 48 percent of commuters into the downtown have used transit in past years, though the proportion has fallen to 43 percent in 1987. The carpool rate is 17 percent. City managers attribute the decline to falling gas prices and some reduction in transit service due to fiscal constraints ("*Parking Management and Traffic Mitigation in Six Cities: Implications for Local Policy,*" Thomas J. Higgins, K.T. Analytics, Inc., paper presented before the Transportation Research Board, January, 1989.)

- ***San Francisco, CA:*** The City's "Transit First" policy influences both the supply and price of parking. The newest Downtown Plan aims at keeping parking supplies very tight and emphasizes short-term parking over long-term. There is no code-required parking in the downtown (C-3) area, and only up to seven percent of a building's gross floor area can be devoted to parking. Under the Downtown Plan, new buildings must have an approved parking plan prior to receiving an occupancy permit. In some cases, only short-term parking is approved; in another, a mix of long-, short- and carpool-parking was approved. City planners generally are satisfied that parking management strategies have helped maintain good transit use and kept auto use to a minimum. Planners indicate there has been no major increase in peak traffic over the past ten years in spite of considerable office growth. Local transit ridership is steady, though ridership on Golden Gate Transit into San Francisco has fallen over the past two years. A 1983 survey of workers in the downtown (C-3 zone) showed 60 percent ride transit, 16 percent rideshare and 17 percent drive alone. (Higgins, op. cit.)

4.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Perhaps no other TDM strategy has as much immediate impact on traveler choice and, hence, vehicle travel demand measures which affect the cost or supply of parking.

They provide an immediate and tangible signal to the traveler of the cost of solo driving relative to the alternatives.

This study reviewed 22 individual TDM programs and both documented the elements of their TDM program and estimated their effectiveness in reducing vehicle travel. These "case studies" are documented and discussed in detail in Part III of this report. While many factors contribute to the success of a given TDM program, it becomes quite apparent when reviewing the experience of these particular programs that parking management measures are key to the performance of the successful examples. Listed in Table 4-1 are the 22 programs and along with their estimated *net* vehicle trip reduction an indication of whether parking supply was restricted or priced at the site. The linkage between the level of impact and the prevalence of parking management becomes evident in this review with the higher impact sites applying some combination of parking pricing and supply restrictions.

This relationship is brought into sharper focus by Tables 4-2A and 4-2B below. These tables place the 22 projects into three trip reduction impact groups: high (> 30% reduction), medium (15% to 30% reduction), and low (<15% reduction). The reduction level is then related to the existence of priced or restricted parking.

Table 4-2A shows that 14 of the case examples employed parking charges. Note that 5 of the 6 sites with impacts over 30% had parking charges as did 7 of the 9 in the medium impact group. In contrast, 5 of the 7 programs in the lowest performance group did not have parking charges. It should be noted that the one firm in the top performance category that did not have parking charges (State Farm Insurance) used a highly successful subsidy strategy instead. And of the two cases that had low impacts while applying parking charges, one (COMSIS) also provides free parking for many senior employees and the other (UCLA) charges a price for parking that is still cheaper than adjacent non-university parking.

Table 4-2B shows a similar result from parking restriction measures. Again, 5 of the top 6 performers had less parking on site than might otherwise be demanded as did all 9 of the employers in the medium impact category. Again, the single program in the high impact group without restricted parking was State Farm which accomplished its' purposes with subsidies.

It should be noted also that instances of parking management measures being applied do not always occur in employers in Central Business District (CBD) locations. Table 4-1 will indicate that application of these measures has been successfully accomplished in the entire range of geographic settings, although supply management is more common than pricing in the more suburban locations as would be expected. Note also that a number of the programs that restrict or price their parking also make an effort to strategically reserve its use by HOV users.

Table 4-1

Effectiveness of Parking Management Measures in Employer TDM Programs

Program	Type Area[1]	Vehicle Trip Reduction	Parking Charges	Restricted Parking	Reserved Parking
•Travelers	CBD	47.9%	Yes	Yes	Yes
US West	SBD	47.1	Yes	Yes	Yes
NRC	ISI	41.6	Yes	Yes	Yes
GEICO	SBD	38.6	Yes	Yes	Yes
CH_2M Hill	SBD	31.2	Yes	Yes	No
State Farm	SBP	30.4	No	No	No
Pacific Bell	SBP	27.8	No	Yes	Yes
Hartford Steam Boiler	CBD	26.5	Yes	Yes	No
Swedish Hospital	ISI	26.1	Yes	Yes	No
Bellevue City Hall	ISI	25.8	Yes	Yes	Yes
San Diego Trust & Savings	CBD	22.7	Yes	Yes	No
Pasadena City Hall	SBD	21.0	Yes	Yes	No
Transamerica	CBD	20.0	Yes	Yes	Yes
ARCO	CBD	19.1	Yes	Yes	No
Varian	SBP	17.7	No	Yes	No
AT&T	SBP	13.4	No	Yes	Yes
Ventura County	OSI	13.0	No	No	No
COMSIS	SBD	10.5	Yes	Yes	No
3M	OSI	9.7	No	No	No
Allergan	SBP	7.0	No	No	Yes
UCLA	ISI	5.5	Yes	Yes	No
Chevron	SBP	3.7	No	No	Yes

[1] Key:
- CBD = Central Business District
- SBD = Suburban Business District
- ISI = Inner Suburb, Isolated
- OSI = Outer Suburb, Isolated
- SBP = Suburban Business Park

TABLE 4-2A

Program Net Trip Reduction	Parking Charges: No	Parking Charges: Yes
>30%	1	5
15 - 30%	2	7
<15%	5	2

TABLE 4-2B

Program Net Trip Reduction	Restricted Parking: No	Restricted Parking: Yes
>30%	1	5
15 - 30%	0	9
<15%	4	3

4.6 COST EFFECTIVENESS

PRICING

Implementation costs will depend on whether a pricing action is merely a change in existing pricing or a whole new pricing scheme. Much also depends on whether or not pricing is packaged with other strategies such as expanded rideshare and transit services. Usually, there is minimal cost in implementing parking price hikes at municipal facilities with pricing in place. Costs for changes in notices and accounting operations are minimal. Implementing new pricing schemes especially combined with increased transit or carpool services can be much more costly. New off-street pricing may entail attendants or meters, and may require new enforcement and accounting procedures. Both Eugene and Santa Cruz implemented comprehensive programs in the early 1980's costing between $30,000 and $50,000 per year in administration and enforcement alone. Additional costs included expanded transit service. However, both programs covered their operating costs in parking revenues and citations.

While the direct costs of implementing parking pricing strategies may not be very great, the resulting economic and financial returns are generally substantial, both in terms of direct revenue as well as effectively reduced vehicle trip demand. For example, when San Francisco implemented the parking tax, gross revenues from the tax amounted to $5.5 million per year. Likewise, price increases in Chicago at municipal facilities resulted in increased revenues even though the City controls only 14 percent of parking space in the CBD. Parkers did not divert to commercial facilities because the price hikes brought prices up to those found at commercial facilities.

SUPPLY MANAGEMENT

Implementation of new parking maximums and flexible parking requirements will have cost and financial implications for both the public and private sector. For the public sector there will be little cost implication, provided only new minimum or maximums are implemented. In this case, the same reviews of developer project proposals must take place as in the past. However, flexible requirements will require more administrative review of proposed traffic mitigation strategies and plans. Plans must be reviewed as to probable effectiveness of proposed strategies and commitment on the part of developers to carry out actions.

For the private sector, cost implications are greater. Where developers provide less parking due to new minimums, maximums or flexible requirements, there will be cost savings in parking spaces provided. The savings vary with the price of parking construction and operation in localities. A recent evaluation of costs and benefits of employer traffic mitigation programs and reduced parking requirements in King County (*"King County Transportation Management Ordinance Cost Benefit Analysis, Technical Memorandum, Task 4,"* July, 1990, K.T. Analytics, Inc. and TDA Inc.) estimated savings in construction costs for structural lots at $4,200 per space and annual operation and maintenance at $200 per year.

On the cost side for the private sector, all depends on the intensity of the traffic mitigation program put in place. A few bike racks, new bus pad, lobby display for promotion of transit and carpooling might cost only a few thousand dollars in one-time costs. An on-site coordinator, regular personalized carpool matching on-site, regular surveying of employees and reporting to a locality may entail an expenditure of several thousand dollars per year. One recent review of employer based traffic mitigation programs at suburban sites found a range of annual costs up to $50 per employee for the most extensive programs. The most extensive programs involved shuttle systems. More typically, costs range from $5 to $20 per employee (*"An Assessment of Travel Demand Approaches at Suburban Activity Centers,"* K.T. Analytics, Inc., for the Transportation Systems Center, July, 1989.)

As an illustration of the cost effectiveness of a parking management strategy, consider a developer allowed or required to reduce the amount of on-site parking in return for implementing a demand management program:

- On the cost side, the developer might be required to hire a part-time TDM Coordinator and secretary and carry out annual surveys, carpool matching, transit promotions and other encouragements for alternatives to solo driving. Assume these annual costs amount to $60,000. Fixed costs might include showers, information centers and bike racks, all of which might amortize out to another $10,000 per year. Total annual costs then are $70,000.

- On the savings side, suppose the developer is allowed to build 1,000 fewer surface spaces. A conservative estimate of amortized savings might be about $900 per stall per year. Amortized over 30 years at 10 percent, the annual savings are about $95,500 per year. Operations and maintenance savings might be $100 per space per year, or $100,000.

On net, the developer enjoys a benefit of about $125,000 per year in spite of having to implement a demand management program. Over 261 working days, the benefit is roughly $500 per day. Even if the demand management program reduces only 100 trips per day, the per trip reduced benefit is $5.00 to the developer. Of course, other benefits accrue to the public at large from reduced traffic and pollution.

4.7 IMPLEMENTATION ISSUES

PRICING

1. Objectives and Instruments

Parking pricing serves the objective of trip reduction. Whether by way of increased rates or surcharges at public and private facilities, removal of parking subsidies, implementation of regulations and developer agreements encouraging parking pricing as a demand management measure, changes in early-bird or other rate schedules in commercial parking, parking taxes or other means, pricing can reduce vehicle trips significantly in both suburban and urban settings.

Objectives will determine what strategies and policy instruments should apply. For lessening localized traffic problems, parking pricing or subsidy removal or changes in public parking rates at employment centers will be effective. However, to achieve regional objectives of improved air quality or trip reduction on routes traversing several jurisdictions, multi-jurisdictional pricing efforts will be necessary. And where private rather than public parking supplies predominate, strategies must focus on commercial parking.

It is important to appreciate that pricing can also bring results opposite to those desired. For example, as some of the examples suggest, pricing can divert some parkers to alternative parking facilities (e.g. Madison), or shorten their parking stay (Chicago) or switch commuters among alternative modes (Seattle). Planners need to anticipate these possible results, along with mode shifts.

2. Implementation

Once objectives are clearly established, the next step is an assessment of certain key variables. Depending on objectives, it will be important to estimate:

- Character and size of the travel market to whom the actions will be applied, including the proportion of through traffic;
- Amount and use of available parking supplies, including overall demand as well as proportion of long- versus short-term use and shoppers versus commuters;
- Availability of parking nearby the priced zone, to assess spillover parking potential;
- Difference between public and private parking supplies and rates, since some parkers may simply shift to commercial facilities if public rates exceed commercial rates;
- Whether pricing mechanisms are already in place or must be stated from scratch (particularly in suburban areas);
- Degree of employer subsidization of employee parking;
- Quality and capacity of transit services, carpool matching programs, bicycling facilities and other alternatives to solo driving;
- Available policy instruments, including demand management ordinances and developer agreements which might be modified to encourage pricing, or state or county funding allocation formulas and legislation (e.g., Congestion Management Plan) which might be modified to encourage pricing; and
- Local regulatory power over commercial parking rates, and authority to implement and enforce parking taxes.

With this information in hand, planners can then devise possible alternatives for consideration. For example, if the objective is to reduce traffic and vehicle trips in a core downtown area or activity center, a good candidate for consideration would include rate hikes or surcharges in public facilities, carpool discounts and public transit encouragements. Important considerations in determining the worth of such strategies include:

- What proportion of parking does the public sector control?
- Are public sector rates below or at a par with commercial rates?
- Is through traffic a large proportion of traffic in the zone?
- Are employees generally subsidized for parking or not?
- Are transit capacity and carpool matching services good or will they be improved with the pricing program?

The simplest public sector pricing option may be to increase rates to near commercial rates without altering rate structure. A more aggressive policy would be to increase rates more for long-term parkers while promoting transit and carpooling. A parking surcharge for morning entry might also be considered, though the surcharge should be applied to most facilities because commuters are likely to simply shift parking destinations if surcharges are in place at only a few facilities. For maximum effect, priced parking permits can be required for parking in the zone both on and off-street.

Implementation rate hikes in the public sector may be the easiest to accomplish of all pricing options. No new authority is required. No new pricing technology or enforcement procedures are needed. Of course, public acceptance and decisionmaker approval may well stand in the way of implementation, but some likely objections can be met with careful planning. Some key issues include:

- Where increased revenues will go;
- Whether shoppers will find more or less parking available;
- Whether parkers will shift to unprotected neighborhood streets; and
- Whether low income workers are disadvantaged.

Collateral actions will be important to implementation feasibility. Important actions to consider include:

- Increased transit and carpool services;
- Preferential parking for residents in nearby neighborhoods;
- Set-aside or validated parking for shoppers;
- Preferential parking by location and rate for carpools; and
- Increased enforcement funded by increased revenues.

One way in which parking pricing might be introduced to areas where parking is currently free and unrestricted in access is to adopt a permitting system such as has been used successfully by Bellevue City Hall (see Part III). Vehicles without current permits would be subject to fines or towing. If priced parking permits are proposed, businesses might be allowed to sell permits on a concession basis. The approach provides some revenue and exposure for local businesses and creates a decentralized permit distribution system.

More difficult than altering public sector parking rates and policies will be influencing private parking pricing. As discussed under Application Setting (Section 4.3), one target of opportunity might be early-bird rates. Localities might ban early-bird rates through regulation, or allow the rate breaks only for very early arrivals. If regulation is not feasible, negotiation may work, especially in localities with parking taxes on commercial parking. An agreement might be struck allowing favorable tax treatment for operators without early-bird rates or monthly discounts.

Another important private sector parking policy to address is employer-subsidized parking for employees. The best way to change this policy is to encourage or require employers subsidizing employee parking to offer cash or a travel allowance as an alternative. Those taking the cash would not receive subsidized parking. This option does not require the employer to offer all employees in the company cash or a travel allowance equivalent to the parking subsidy. As such, the option strives to maintain, not increase, the net employer outlay on parking, thereby enhancing prospects for acceptance and feasibility. Of course, a variation would be to require employers offering any employees parking subsidies to offer all employees the cash equivalent. This approach would increase employer outlays for employee transportation and likely meet with more resistance.

The parking tax is another option for influencing commercial parking rates. As the case of San Francisco shows, the tax may have to be quite substantial to influence parking rates, so it is important for local planners to assess the political perspectives on such taxes as part of assessing feasibility. Parking taxes also will require a collection mechanism. Depending on how the tax is applied, parking operators would have to file a tax return form identifying parking facilities, rates charged, number of spaces, and proportion of lease parking or long-term parking. Depending on the expected volume of returns and the tax collection burden, reports and collection might occur annually or quarterly.

Where pricing is to be coordinated across several localities, higher-level government participation might be necessary. For example, in California, the Congestion Management Plan legislation requires all localities to develop demand management programs, with attention to parking pricing and management among other strategies, as a condition of receiving state funding for facility improvements. The regulation also specifies that traffic congestion must not deteriorate below certain levels as a condition for receiving funding. Thus, the legislation provides an incentive for congested localities to consider parking pricing strategies. State and Federal air quality regulations may also provide an impetus for regional parking management plans.

Finally, any parking pricing scheme must be monitored and evaluated. Parking managers and planners should track:

- Mode shares of commuters into the zone;
- Parking utilization and turnover at priced facilities and at nearby facilities and streets;
- Parking violations and meter feeding. Some commuters can be expected to feed meters and shuffle cars in time-restricted zones; and
- Parking revenues, along with any increased costs associated with the program.

SUPPLY MANAGEMENT

1. Objectives and Instruments

Parking supply measures support the objective of trip reduction. Revising minimum or maximum rates, allowing below minimum rates in proximity to transit or for demand management programs, and providing shared parking at mixed-use developments, are all important considerations in a trip reduction program.

As with pricing, program objectives will determine what strategies and policy instruments should apply. For new developments in proximity to transit, maximum rates and controls on street parking will provide the maximum incentive for transit use. Maximums are especially important to consider in proximity to suburban rail stations, in light of findings previously discussed about excess parking supplies in many suburban developments. Adding carpool stalls where supply is limited will provide an incentive for pooling, especially where stalls can be located to shorten walks to building entrances. Also worthwhile are flexible requirements allowing for reductions in normal on-site minimum parking requirements in return for support of ridesharing and transit encouragements, peripheral parking and transit facilities.

2. Implementation

Implementing maximum rates or flexible parking requirements does not involve significant implementation barriers. Nor are there difficulties in specifying designated carpool parking in developer agreements or codes. Localities typically have the authority to regulate parking supplies by way of parking requirements in codes. Thus, only code modifications are required, supported by periodic parking demand studies.

While code modifications are not difficult, they should be made cautiously. Several localities have instituted maximums and flexible requirements with unexpected results. For example, several cities have provided for optional relaxations in parking requirements for various purposes (support of peripheral parking, ridesharing and transit encouragements, in-lieu funds) only to find developers not taking advantage of relaxations. Los Angeles, Hartford, Seattle, Bellevue, San Francisco and Orlando all provide examples. In Los Angeles it appears the flexible requirement attached too many burdensome requirements to attract developers. In Hartford, the fringe parking provisions were not considered a burden by developers, but developers did not want to operate shuttles over the long-term. Peripheral lots were not perceived as a good alternative for employees. No fringe parking has developed under the flexible parking code. Developers prefer simply to lease nearby surface lots for employees who then walk a block or two to work. In all these locations, the cost of providing parking on-site is substantial.

The implementation lessons for localities are as follows:

- Careful assessments must be made to determine levels of parking demand and lender and developer preferences before instituting maximums, minimums or flexible requirements.

- Incentives for reduced requirements must be attractive not only to employees but to developers as well. Generally, developers prefer one-time actions or fees rather than long-term operational commitments as incentives for any public benefit action. For example, developers in Chicago routinely take advantage of relaxations in minimum parking requirements in return for physical connections between office developments and transit stations. However, as the Hartford case suggests, developers are much less inclined to operate park-and-ride service over some extended period of time. They probably would prefer to make one-time payments to a fringe or regional park-and-ride lot system.

- Tight maximum requirements near transit stations and trunk lines should be implemented only after assessing what the market (developers and lenders) provides and prefers to provide, and what is the current level of parking demand in the vicinity of transit facilities. This approach minimizes the risks of setting maximums above usual levels of demand and/or market preference.

The best overall approach for implementation of all parking supply measures is to proceed step by step and evaluate policies along the way. For example, with respect to parking maximums, a preferred approach is first to implement maximum requirements in the immediate vicinity of transit corridors and major terminals, or at the largest developments subject to the most demand management requirements. Depending on outcomes, the policy might be expanded to other locations and employment sites. With respect to fringe and intercept parking at a few facilities, the best approach is to start through joint-use arrangements to minimize cost and allow for easy modification of the program. Any such test should involve frequent shuttle service, low or no fares, and design and safety considerations (*"Commuter Parking Lots: Vandalism and Deterrence,"* Alan N. Mancini and Rejendra Jain, Transportation Quarterly, Vol. 41, No. 4, Oct. 1987).

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B.5 TOLLS AND CONGESTION PRICING

5.1 DESCRIPTION OF STRATEGY

CONTEXT

It is increasingly being accepted that payments by automobile users through the existing road user charges and other vehicle related taxes fall far short of the costs occasioned by these users, particularly when the trips are made in congested situations.

These subsidies have nurtured and exacerbated many of the peak period traffic and transportation problems now being faced in urban and suburban areas, as traffic congestion has increased dramatically and spread across the metropolitan area. Road and public transportation productivies and efficiencies have declined, while society is paying a large price in terms of air pollution, lost time and overall decline in economic productivity.

In this context, many observers believe that the so called "market/pricing approaches" (which aim to manage travel demand through pricing incentives/disincentives) could play a major role in improving the overall transportation situation and lead to greater economic efficiency and a cleaner environment.

Incentives for transit and ridesharing, such as fare and other subsidies and preferential treatments, have been proposed and implemented. Often these actions have been justified under the "second-best" concept in economics, which says that benefits would accrue to society by subsidizing alternatives to automobile, if automobile travel enjoys subsidies. Unfortunately, however, the impacts of such incentives for transit and ridesharing on vehicle travel typically have been modest, at best. Even where successful, often the latent demand for automobile travel has consumed the resulting spare road capacity. Moreover, such strategies have put large additional burdens on already strapped local transportation finances.

MARKET-BASED STRATEGIES/PRICING AUTOMOBILE USE

There is increasing recognition that, in comparison to the incentives for alternatives to the automobile, direct pricing of automobile use can be much more effective in reducing VMTs and related problems. Such direct pricing of automobile use also has the potential to sustain the reductions in travel over time by suppressing the latent demand. Furthermore, such prices could generate large new revenues from road users.

A relatively well-known automobile pricing approach is to introduce/increase prices for parking. However, parking pricing generally can be expected to produce only modest reductions in traffic. First, it leaves out all through traffic, which typically makes up a significant proportion of traffic in an area. Second, prevalence of large amounts of private and residential spaces within an area and in the vicinity makes it difficult to introduce parking prices that would cover a large proportion of automobile users in the area due to spillover opportunities. Third, widespread practice of subsidized parking (by employers and retailers) is likely to heavily undermine the effectiveness of most parking pricing strategies.

The most direct pricing approach -- pricing of automobile use where prices are directly or indirectly related to actual road use -- probably has the greatest potential for VMT reduction. Commonly suggested alternative direct pricing strategies include: gasoline taxes, other proposals such as "at-the-pump" insurance or other levies, and vehicle registration fees varying with annual VMTs. While these pricing strategies could produce VMT reductions if set high enough, they are not suited to produce differential trip reductions that vary by the level of congestion, time and location. As a result, they lack the specificity which is important to achieve economic efficiency.

CONGESTION/ROAD PRICING

Road pricing, where road users are charged differential rates varying by time of day and location depending on the level of congestion, is the most direct congestion pricing approach and promises the greatest potential for reducing VMTs, as needed, compared to the common market-based strategies described above, since congestion and related problems are location and time specific, this pricing strategy has the potential to implement differential prices so as to maximize the economic efficiency in the transportation sector.

Economists have long argued for tolls set by time of day and vehicle occupancy to reduce congestion. The literature suggests prices in the range of $.10 to $.30 per mile would bring congested highways to optimum traffic flow ("*Estimates of Optimal Congestion Tolls*," Robert McGillivray, The Urban Institute, 1974).

In congestion pricing, governments impose fees for entering a congested zone ("area-wide pricing") or traveling on congested highways ("tolls"). Congestion pricing may be imposed by toll booths, electronic devices (automatic vehicle identification, or "AVI") or special permits.

In the case of permits, vehicles are required to display a special windshield sticker or license (daily, weekly) when using roads during designated time periods. Such a program has been used since 1975 to administer an area-wide congestion pricing program in downtown Singapore.

Alternatively, electronic (or optical) licenses mounted on vehicles might be used. In this scheme, each vehicle would be fitted with an electronic "box" or optical "strip" carrying either a unique identifier or a prepaid "cassette" carrying certain dollars worth of travel privilege. Road side electronic (or optical) "interrogators" administer the road user charges. In the identifier option, each vehicle is identified as it passes by an interrogator and an appropriate charge is billed later, most likely through the mail like a telephone bill. In the option using prepaid licenses, interrogators automatically debit the appropriate user charge.

5.2 NATURE OF EFFECTIVENESS

Congestion pricing can encourage some peak period road users to shift to off-peak periods, to high occupancy vehicle modes, to less congested destinations, and/or to forego certain trips. Such changes in travel behavior can bring about significant improvements in regional mobility.

The potential benefits through reduced delays to road and transit users, from enhanced transit productivity and reliability, via reduced emissions and energy consumption, and from more productive organization of economic activities can be expected to outweigh the costs of implementing such charges at highly congested facilities. Further, congestion pricing of roads promises to generate large revenues for the localities.

As mentioned earlier, congestion pricing could be expected to be more effective in reducing travel than parking pricing under comparable areal and price contexts since it would include through traffic that parking pricing would leave out. Also, with careful geographic design, opportunities for spillover and price avoidance could be minimized more easily under a congestion pricing project than under parking pricing. The existing practices, such as subsidized parking and the generous interpretation by IRS of parking subsidies as a tax-free benefit to recipients, also undermine the effectiveness of parking pricing. In contrast, subsidies against congestion pricing may not qualify as tax-free allowances, and this could discourage employers from widespread subsidization of employee road charges. Road pricing also tend to suppress the latent demand and thus sustain traffic reductions over a much longer period. This is a particularly attractive feature of road pricing compared to parking pricing and other more common TDM strategies which typically do little to discourage latent travel demand, or travel on the roads and, thus, too often allow the traffic reductions to be short lived.

Road pricing also has certain advantages from the effectiveness standpoint over more general and nonspecific automobile use prices such as fuel taxes, "at-the-pump" imposts and VMT-based registration fees. While these other prices can reduce travel, they are not expected to reduce travel at selected locations and times. In contrast, congestion pricing can be highly time and location specific and has the potential to produce just the desired reductions at the desired locations and times. In this respect, congestion pricing promises the most efficient and equitable outcomes. It promises the closest match between the trips that create problems and occasional costs and their payments. It is these time and locational differentials that raise traveler interest not only alternative modes, like other TDM strategies, but also raise consideration of alternative times, routes and destinations and, thus, encourage relatively greater reductions in the most undesirable travel.

The greater opportunities afforded to the priced travelers for changing routes times and destinations does mean, however, that congestion pricing carries the danger of undesirable spillover. The areal and temporal design of any congestion pricing project would need careful planning to safeguard against undesirable spillovers and to minimize the danger of simply shifting the congestion problem in time or space.

The effects of applying such congestion pricing strategies will depend, among other things, on the level of charges, travel characteristics and alternative travel opportunities:

- **The level of user charges**: The charge levels are based on the congestion and type of facility or area, although practical administrative and acceptability considerations might require charges to be somewhat higher or lower than the "most efficient" ones.

- **Availability of alternatives**: Impacts of congestion pricing will depend on the quality of alternative modes, the opportunity to shift to lower-priced time periods and lower-priced facilities. Where transit and other HOV modes are attractive and accompany congestion pricing, larger reductions in automobile travel can be expected compared to pricing with poor alternatives.

- **Peak pricing**: If congestion pricing focuses on peak period travel only, then considerable shifts in travel from peak to off-peak periods can be expected. In such a case, while the overall reduction in daily trips might be dramatic, the shifts from peak to off-peak travel can bring significant reduction in congestion and emissions.

- **Work patterns**: In addition to reductions in solo driving and peak period travel over the short run, possible long term benefits include additional trip elimination through greater participation in telecommuting and compressed work week programs encouraged by road pricing. Over the long run, congestion pricing also could encourage less travel-intensive land use patterns.

5.3 APPLICATION SETTING

Congestion pricing can be applied in different settings depending upon the local situation regarding congestion and other related problems, and the local traffic reduction and environmental goals.

If congestion is confined to one or few urban or suburban bottlenecks such as bridge or tunnel crossings or a freeway segment, or if such a crossing or facility captures a significant proportion of traffic causing congestion within a corridor close by, congestion pricing at the crossing(s) could produce large benefits. Where congestion is extensive within a travel corridor, pricing of major facilities within the corridor would make sense. Extensive congestion over a regional freeway network would call for pricing of the major portion of the network. Finally, if congestion over local street system is endemic, as in a downtown area, area-wide street system pricing would be appropriate.

The local geographic features and network configurations could have an impact on the exact boundaries and application. For instance, potential for large spillover to key uncongested facilities in the vicinity of the priced facilities may require inclusion of the uncongested facility in the pricing program. Similarly, availability of existing toll collection infrastructure at particular location may suggest its inclusion as a pricing point even if the heavy congestion is some distance away, but would be affected favorably by the pricing.

Unlike most other more common TDM strategies which focus exclusively on work trip reductions, congestion pricing could also include and influence non-work trips, which would be a major benefit of this strategy over commute-based TDM. This would require application of pricing requirements outside of the peak travel periods.

Congestion pricing can be expected to be most effective where congestion is severe and where there are good alternatives to travel at congested times and places. In the best case, transit capacity and service into the priced zone are good, park and ride alternatives are available, alternative travel routes are not congested and the number of entry and pricing points are minimized. In the worst case, transit service is not good or is at capacity, alternative travel routes are congested and numerous pricing points are necessary. In the latter case, commuters facing the pricing schemes are more likely simply to pay the travel price instead of changing modes or time of travel. Administration and enforcement costs also will be greater.

Clearly, congestion pricing can support other demand management strategies, and prosper along with them. Employees in a priced zone will have a strong incentive to travel outside the priced peak period, to form carpools or to take transit. Telecommuting also will be a more favored option.

Overall, congestion pricing is most appropriate to consider in very congested urban cities and highway corridors. An elaborate system of permit or AVI distribution outlets, a new enforcement force, electronic pricing points, and citation mailing systems can be justified only where congestion is sufficiently severe that the benefits of reduced congestion outweigh program costs. Also, in such congested areas, travelers are most likely to find the greatest availability of transit and other demand management options, and travelers paying the charges will perceive the greater gains in travel time. Finally, decision makers and the public are most likely to see benefits in congestion pricing in terms of improved air quality and quality of life.

5.4 EXAMPLES

Examples of congestion pricing are limited. However, examples and projections suggest the strategy can be very effective in reducing traffic, electronic charging systems are feasible, and revenues most likely will exceed costs. Examples include:

- **Singapore**: An Area Licensing Scheme (ALS) in Singapore is the longest-standing example of congestion pricing. Operational since 1975, the ALS covers the congested central business district of over 2.0 square miles. Passenger cars carrying less than four occupants traveling into the priced area from 7:30 to 10:15 in the morning must display priced permits. The fee is approximately U.S. $2.50 per day (over the first few years, the fee was $1.30). Daily licenses can be bought at roadside stands on approach roads and selected post offices. They can be bought in advance. Monthly licenses are also available. Fifty enforcers at 28 crossing points into the area enforce the scheme. Violators are cited by mail. The fine for traveling without the license was set at U.S. $23 for first offense and increased sharply for repeat offenders. Bus service was improved into the core area, and park-and-ride lots were added on approach roads.

  Effects of the program have been dramatic. Peak period traffic entering the priced area has fallen by over 40 percent. Severe congestion in the area has been eliminated. Carpools made up 23 percent of the vehicles entering the area before the program, and 45 percent of the vehicles after the program. Bus share went up from 33 to 46 percent. The ALS program apparently has not measurably affected business activity or rents within the area. On the negative side, traffic on peripheral bypass roads has increased considerably. Speeds on these roads fell by about 20 percent. Also, the volume of cars entering the zone before 7:30 a.m. rose by 23 percent ("*Relieving Traffic Congestion: The Singapore Area License Scheme*," Peter Watson and Edward Holland, The World Bank, February 1978). Furthermore, the afternoon peak congestion has not been reduced significantly.

- **Hong Kong**: Hong Kong experimented with an area-wide congestion pricing pilot program in the downtown core using Electronic Licenses (EL) for several months during 1985. The program consisted of fitting 2,600 cars (public vehicles and volunteers) with an Electronic License Box and 18 interrogator loops buried in the road with roadside processors connected to a central computer. When a car with an EL passed by the interrogator, it was identified and the appropriate predetermined charge was posted to that car's account by the central computer. The owner was then billed periodically. Cameras were installed to identify cars not registering the correct signal. The pilot project showed that Electronic License technology was completely feasible for detecting and charging prices. Traffic models projected that a full-scale congestion pricing program would reduce peak period traffic by 20 percent, although off-peak traffic would probably increase by 20 percent. The capital cost, including EL Boxes would be $30 million and annual operating costs would be $2.5 million. The revenues from congestion pricing were estimated to be many times the operating costs.

Over the last few years, several localities in the U.S. and Western Europe are looking at congestion pricing with more favor. The important point here is that many of these programs have evolved under local initiatives. Also, these programs represent a socioeconomic and political context much closer to home than Singapore or Hong Kong.

- **Oslo and Bergen**: A central area pricing program using manual toll collecting points has been in operation in Bergen, Norway since 1986 (Larson). In early 1990, Oslo set up 18 "toll points" around the city center. The charge is about $2.00 per day. It can be paid manually at the place of passage or windshield permits can be prepurchased, allowing passage along a special entry lane. License plate video surveillance is used to enforce this program. Electronic tags may replace windscreen badges in the near future. Since the underlying aim is to generate revenues, information about traffic impacts is not available.

- **Stockholm and Malmo**: Over the last three years, the Swedish government has evaluated road pricing options to address congestion and air quality problems in several cities including Stockholm and Malmo. The proposal for area-wide road pricing for the inner city area of Stockholm calls for the use of both Singapore-type Supplementary Licenses and AVL.

- **Netherlands**: The Dutch government is proposing to implement a large-scale road pricing scheme covering extensive areas of Eastern Holland in 1992-1995. Road users would pay for crossing multiple cordons. The aim is to limit congestion, reduce environmental pollution and raise revenues for major new highway construction. The technology under development would involve the use of prepaid cassettes to be interrogated remotely from roadside without requiring slowing down. This would enable charges varying with time and location.

- **London**: A plan for London proposed pricing vehicles traveling between 8:00 a.m. and 6:00 p.m. in the central 10 square-mile area. The prices were to administered through daily and monthly supplementary licenses. Licenses were to be sold, at commission, through automats, newspaper kiosks, post offices, service stations, banks and other retail outlets in the metropolitan area. Planners developed detailed administrative, monitoring and enforcement procedures. The model-based evaluation suggested that a daily price of $2.50 would decrease automobile traffic by 37 percent. Annual revenues were estimated to be around $70 million. Annual cost of running the pricing program was estimated to be less than 10 percent of the revenues, leaving substantial sums to finance the planned collateral expansion of transit service.

  Since early 1991, London has reembarked on a comprehensive five-year feasibility and design study aimed at implementing congestion pricing programs. Initial efforts have focused on technology development and generation of supporting constituency.

- **Boston**: A 1978 study for downtown Boston suggested that road pricing of $1.00 to $2.00 per day on local streets in the 3.5 square-mile central area would drop peak period automobile trips and VMT by up to 50 percent; transit trips would increase by more than 40 percent; and traffic speeds would increase as much as 150 percent. On the regional level, the VMT reductions could be up to 10 percent. This would imply 50 percent-or-greater reduction in CO emissions in the Central Area, as much as 11 percent reduction in regional hydrocarbon emissions, and up to 10 percent reduction in the regional fuel consumption. These prices also could generate as much as 20 million dollars annually in new revenues. The annual costs, not estimated in the study, might be on the order of $2.0 million.

- **Los Angeles**: Model results in Los Angeles suggest that road use charges on the order of $5.00 per day on Los Angeles Basin highways could cut peak period traffic at the upwind end of Basin by about a quarter, at a system cost of $.15 to $.30 per trip. This reduction would represent a 4.5 percent reduction in regional traffic and related emissions.

- **Manhattan**: A 1986 study of area-wide congestion pricing for the entire area south of 64th Street in Manhattan estimated that a daily price of $5.00 per automobile entering the area between 6:00 a.m. and 12:00 noon could reduce the six-hour trips entering into Manhattan by 20 percent. The reduction represents 3.7 percent of total daily trips to Manhattan. The program could generate over $100 million in annual revenues at a start-up cost of $12 million and an annual operating cost of under $10 million.

- **Other U.S. Cities**: Preliminary assessments of area congestion pricing for half a dozen U.S. cities by the Urban Institute in the 1970s suggest that a daily peak period charge of $2.00 for downtown would reduce peak period trips by 25 percent, and generate annual revenues of $5 to $10 million at an annual cost around $0.5 million.

RECENT U.S. INITIATIVES

We have yet to implement congestion pricing seriously in the U.S. However, two types of recent initiatives that bear on the future of congestion pricing in this country are worth mentioning:

- Automatic toll collection
- Congestion pricing feasibility studies

Automatic Toll Collection: Over the last decade, several toll roads and bridges in the U.S. have started using, or are about to implement, automatic electronic toll collection techniques. The fully operational systems include facilities in Texas, Oklahoma, Louisiana, Colorado, Florida, Michigan, and California. Two examples are: Coronado Bridge in San Diego and North Dallas Toll Road. These operations have proven the effectiveness of AVI for toll collection.

Automatic electronic toll collection systems are being planned for near-term implementation in the New York City area, and in the states of New York, New Jersey, Pennsylvania, California, and elsewhere. (There are also numerous applications in Europe and elsewhere.) While none of these have congestion pricing features (tolls varying by time of day), they could easily introduce such differential rates using the existing technology. They represent successful use of the technology that may be appropriate for congestion pricing applications, although all the users in these applications are voluntary participants. Furthermore, all these applications require vehicles to slow down considerably, though not come to a complete stop when crossing the toll point(s).

Most congestion pricing applications would probably need to deal with involuntary participants. Also, many fully comprehensive congestion pricing applications probably would need to go a step beyond the existing technological capabilities by allowing toll collection without having the vehicles slow down dramatically. Both of these requirements probably call for further evolution in the AVI or Smartcard technology used in existing toll applications.

The experience of these automatic toll collection systems is invaluable as we pursue congestion pricing. First, some of them might be willing to consider congestion pricing requiring them only to set up a price differential between peak and off-peak periods. Second, they provide a testing ground for the automatic charging technologies and their variations which may be more appropriate for congestion pricing. Third, some of these may provide an opportunity to address certain legal and institutional issues which are likely to arise in the context of congestion pricing.

***Recent Congestion Pricing Initiatives in U.S.*:**

- **Los Angeles Region**: The Southern California Association of Governments (SCAG) has been examining the possibility of implementing congestion pricing in the Los Angeles region at major activity centers and over the congested freeway network to address the growing problems of severe congestion, pollution and transportation revenue shortfalls, SCAG completed a preliminary consultant study in 1991.

  The Environmental Defense Fund also published a report last year developing effective approaches to tackle the region's severe emissions problem and congestion pricing in a key proposed measure.

  Perhaps the most promising are the proposals to introduce congestion pricing at the new private toll roads in the region. At least one, if not more, of the three private toll roads being built in Orange County under California's AB-680 program appear to be willing to introduce peak/off-peak toll differentials instead of flat tolls. The SR-91 project, now under construction, may agree to do it. Similarly, there are proposals, by private individuals, to introduce congestion pricing at one or more of the proposed Corridor Transportation Agency toll roads in southern Orange County. Some have proposed making the planned free HOV lanes along the San Joaquin Foothills Corridor Toll Road premium congestion priced lanes instead.

- **San Francisco**: The Bay Area Air Quality Management District and MTC have recently examined the possible application of congestion pricing at the major bridges in the region and for the congested freeway network to address peak period congestion and automobile emission problems. There has been support for this from independent regional associations of private/public interests, such as the Bay Area Forum. Congestion pricing measures have been a part of several transportation control measures under consideration for meeting emissions standards. After public debate last year, congestion pricing was demoted to the category of possible future measures.

- **San Diego**: SANDAG, the regional association of governments is preparing an implementation plan under an FTA grant to implement a two-year demonstration project of a congestion pricing concept in the region. The proposal calls for allowing solo drivers access to the 8-mile expressway HOV lane in the median of I-15 during peak periods in return for payments.

- **FHWA and FTA Demonstrations**: Sine late 1981, the Federal Transit Administration (USDOT) has set up a congestion pricing demonstration program to assist interested localities with demonstration funds.

  The Intermodal Surface Transportation Efficiency Act (ISTEA) enacted in late 1991 has set up a congestion pricing demonstration pilot program to be administered by the FHWA. It authorizes $25 million per year for six years to assist localities and states with implementing congestion pricing demonstrations. FHWA has published a Federal Register Notice which describes the program, selection criteria, eligibility criteria and formally solicits applications for participation by local and state entities. A large-scale research, development, implementation, and evaluation program is being designed. In June 1992, FHWA and FTA jointly sponsored a national symposium in the Washington, DC area to address the key conceptual, design, economic, technological, feasibility, and acceptability issues. The Symposium Proceedings have been published and provide substantive discussions about the key issues and future directions.

5.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

Depending on the scope, extent, and price level of application, congestion pricing can be highly effective in reducing vehicle trips, particularly where the peak to off-peak price differentials are large and where pricing covers many trips evidence. Evidence from Singapore and estimates from numerous studies in the U.S. and western Europe suggest peak period traffic reductions of 30 percent or more are possible, particularly if pricing is packaged with expansion of HOV modes. Such reductions could produce dramatic improvements in congestion and speeds in the affected areas and facilities. Significant improvements in air quality could be realized as a result of pricing. Again, evidence from Singapore and estimates form U.S. and European studies suggest reductions of five percent or more in major pollutants are possible through congestion pricing. For instance:

- Peak period area licensing scheme in Singapore reduced inbound peak period traffic by 40 percent.

- The Hong Kong study estimated a reduction of 20 percent in peak period traffic in the congested areas and significant increases in speed.

- The Stockholm study estimated that road pricing covering the inner city area would reduce automobile trips to the inner city by 28 percent, increase speeds by 30 percent, and reduce CO and NOX emissions by 18 percent.

- A London study in the 1970s had estimated a reduction in automobile trips to the city center of 37 percent.

- A 1978 study for Boston suggested that a central area pricing scheme could reduce peak period trips to the area by up to 50 percent and produce speed increases of up to 150 percent.

- A 1986 study of area-wide pricing in lower Manhattan estimated a reduction of 20 percent in the 6:00 a.m. to 12:00 noon period trips to the affected area. This would have increased peak period speeds in the Lower Manhattan area by more than 50 percent.

- Recent studies in the Southern California and San Francisco Bay areas have estimated that congestion pricing programs could reduce affected peak period trips by 10 to 20 percent and increase peak speeds dramatically.

While evidence and estimates suggest significant potential reductions in trips to the priced areas or on the priced facilities, certain spillover problems could be encountered. For instance, in Singapore, travel on the peripheral by-pass route increased significantly during the priced periods. Mini peaks were also encountered immediately before and after the pricing period, until the pricing period was expanded. The 1978 Boston study also projected significant increases in traffic on peripheral routes. While some of the alternative routes and off-peak periods could accommodate some increased traffic without major problems, each congestion pricing project will have to carefully assess spillover potential to minimize undesirable traffic spillovers. The program boundaries (both geographic and temporal) would need to be designed carefully; alternative modes would need to be expanded to provide viable options; and other traffic measures to reduce spillovers would have to be considered.

5.6 COST EFFECTIVENESS

Costs of implementing congestion pricing will depend on the program dimensions as well as the mechanism or technology selected. The larger the geographical and temporal coverage of the application, the greater would be the likely costs, although not necessarily proportionately so. More complexity in prices (e.g., greater price differentials by location, time, type of vehicle, or occupancy) would require more expensive administration and enforcement.

Any of the effective congestion pricing programs will entail significant start up costs including a comprehensive planning effort, extensive information dissemination and outreach, and investment in required signs and hardware. These costs might be no more than several thousand dollars for a program (such as in Singapore), with few pricing points requiring few road signs, and the simple technology of supplementary licenses. On the other hand, a large area-wide program such as proposed for Hong Kong using AVI (Electronic Licenses) to charge a complex rate structure would require a lot of sophisticated on-vehicle and roadside hardware. Such a program would incur an initial investment of several million dollars or more.

Ongoing operating costs would include collection of charges, monitoring and enforcement. Again, the costs will depend on the technology selected and the enforcement needs as governed by the complexity of the price structure and on the area of coverage (Bhatt). For instance, studies in the U.S. suggested that pricing of a 1.0 or 2.0 square mile area through supplementary licenses may cost a few million dollars per year to operate. Pricing of large areas covering a large fleet of vehicles, as in the New York or London proposals cited earlier, might entail annual operating costs of $10 million or more.

Perhaps even more important for costing are the types of collateral measures packaged with congestion pricing. At the least, these might include expansion of transit, park-and-ride, ridematching, and HOV facilities and services. Additionally, some observers have suggested reducing business taxes or vehicle user fees (e.g., registration) as part of a compromise package making congestion pricing feasible ("*Roadpricing: A Clash of Analysis and Politics,*" Thomas J. Higgins, Policy Analysis, Vol. 7, no. 1, Winter 1981). These costs could add up to millions of dollars in a large-scale program, at least through a demonstration phase.

While the costs associated with congestion pricing programs are expected to be quite large, the programs also would be expected to generate significant revenues. As described earlier, the new pricing revenues are likely to exceed the initial investment and operating costs of the pricing component (typically 10 to 20 times the operating costs). This would enable many alternative mode expansions and other mitigating collateral actions to be funded.

One detailed proposal for a Singapore-type pricing scheme in Berkeley, California in 1978 illustrates the cost effectiveness of congestion pricing ("*A Road Pricing and Transit Improvement Program in Berkeley, California,*" Melvyn Cheslow, The Urban

Institute, Washington, DC, 1978). Several alternative combinations of pricing and transit expansion were examined, all of which generated revenues equal to or exceeding costs. For example, a charge of $1.00 for entry into the core area of the city during the a.m. peak combined with new a.m. and p.m. transit service and park-and-ride facilities cost $1.8 million annually (transit operating and capital costs as well as pricing administration and enforcement) and generated $4.2 million annually (pricing and transit fares) providing $2.4 million in net revenues. Projections estimated 9,000 daily automobile trips reduced. Because revenues exceed costs, trips are reduced at no net cost. However, excluding revenues, cost per daily trip reduced is $0.77 in 1978 dollars, presuming costs are allocated over 261 days per year.

A "break even" case also was examined in Berkeley. The case shows extensive all-day transit improvements can be funded by peak period congestion pricing. A $1.00 charge for entering a citywide program area during the a.m. peak combined with new 14-hour per day transit service and park-and-ride facilities would generate annual revenues of $14 million (pricing and fares) at a cost (transit and pricing program) equaling revenues. Daily automobile round trips would be reduced by 22,000 and transit ridership increased by 17,000. Again, excluding revenues, cost per trip reduced is $2.44, presuming 261 days per year of operations.

While congestion pricing programs require considerable administrative, enforcement, and outreach efforts and incur significant costs, they are expected to generate large revenues--on the order of 10 times the costs or more. This revenue potential is likely to be a major attraction of congestion pricing to many localities. Traditional sources of financing for transportation have been shrinking at a time when the needs go unmet.

On the other hand, the prospects of large revenues probably will require much cooperation and coordination among local interests. Interjurisdictional agreements might be needed to administer the program and collect revenues and to determine how to share and use the revenues. The possible uses are many: expansion of road capacity, expansion of alternative modes, tax relief, substitution of existing revenue sources, and subsidies to selected adversely affected travelers and businesses. The June FHWA/FTA Symposium on congestion pricing suggested that a resolution of these issues might be critical from the standpoint of acceptability of congestion pricing proposals.

5.7 IMPLEMENTATION ISSUES

The first consideration in implementation is insuring the proposed congestion pricing approach matches the problem it is to address. For example, if severe congestion is the main impetus for pricing and congestion plagues primarily the highway network rather than local streets, network congestion pricing should receive attention. On the other hand, if air pollution is the driving consideration, then large area-wide programs might make more sense. Similarly, daily travel characterized by a congested morning peak would suggest peak period pricing strategies. If regional centers rival for development and there is strong concern about diversion of development and business activity between various centers, then pricing of selected facilities or pricing across several major centers should be considered.

Once a congestion pricing proposal is derived to match with the problems it is to address, attention can turn to implementation issues. Congestion pricing faces major concerns about administration, enforcement and acceptability as was emphasized at the FHWA/FTA Symposium. The strategy will require new technology and administrative practices to collect the user charges. Effective enforcement probably will require novel methods. New legislation/ordinances might become necessary. The strategy is likely to have far-reaching impacts on regional travel and economic activities. There will be winners and losers. All of this suggests considerable risk. Public acceptance and political support will require careful nurturing.

The key issues needing attention include:

- **Acceptance:** Experience suggests area-wide congestion pricing faces significant problems of acceptability. The federal government in the mid-1970s offered cities funding to support demonstration of a Singapore-like congestion pricing program. Most U.S. mayors turned down the offer, citing the need "to maintain competitive position with suburban centers" (Mayor of Baltimore) and "potential practical, technical, political, and financial problems" (Mayor of Atlanta). Some cities did request preliminary studies of the concept, including Berkeley, California; Madison, Wisconsin; and Honolulu, Hawaii. While the studies carried out by consultants suggested congestion pricing would bring major reductions in traffic, little harm to business (if prices were imposed only in peak periods) and revenues far exceeding costs, the opposition was so great from businesses, community groups and the media that all studies were terminated before demonstration plans could be developed ("*Road Pricing Attempts in the United States*," Thomas Higgins, Transportation Research, Vol. 20 A, No. 2, 1986).

  Obviously, if the public objects strongly to area-wide congestion pricing, the effectiveness of the system may be compromised. For example, users might defeat the requirement for priced permits by using counterfeit or used permits, refusing to buy permits altogether, using unregistered vehicles, or not responding to mail citations. Defeat of AVI may take the form of deliberate damage to the license, use of signal blocking devices, or the use of expired licenses.

Congestion pricing on highways appears more feasible than area-wide applications. In fact, congestion pricing will soon be implemented in California on new toll roads being built by the private sector under provisions of AB680. The "Orange Lanes" project on Route 91 in Orange County is planned as an AVI toll road with tolls at $2.00 peak and $1.00 off-peak. Carpools would be free. Route 57 in southern California also will employ congestion pricing strategies with tolls as high as $5.00 daytime and $3.00 nighttime (*Newsline*, Orange County Transportation Commission, October 1990).

- **Legality**: Another possible implementation hurdle is legality. While congestion pricing on new privately-built facilities is feasible in California, tolls of any kind on federally-aided facilities face an important legal barrier. Section 129, Title 23 of the U.S. Code effectively bans toll roads on federally-aided facilities. Only on the basis of exceptions have states been allowed to use federal funds to construct toll bridges, tunnels and approaches to federal-aid highways. In these exceptions, states must agree to discontinue tolls upon retirement of bond indebtedness (ISTEA does authorize FHWA to exempt up to three projects under the new Congestion Pricing Pilot Program Demonstrations from this restriction).

- **Operations and Enforcement**: Implementation issues also surround operations and enforcement. New legislation may be required to carry out effective enforcement. The Singapore area-wide scheme requires a distribution system for sale of permits and a large force of monitors stationed at all entry points around the priced zone. These enforcers note vehicle license plates and mail citations to vehicle owners. In an electronic version of the system successfully tested in Hong Kong ("*Electronic Congestion Pricing in Hong Kong,*" Harrison, Traffic Engineering and Control, January 1986), AVI identifies electronic tags on vehicles, imposes a price, and bills registered vehicle owners by mail. Enforcement is accomplished by mailing citations to vehicle owners. In many states new legislation would be required to allow vehicle owners as opposed to drivers to be liable for a congestion pricing violation. Only one state has passed such legislation. The City of New York recently obtained state legislation making the vehicle owner liable for moving violations, except for cases of a stolen vehicle.

- **Demonstration Phase**: Experience with congestion pricing in the U.S. is sufficiently limited that first implementation attempts may be with help from federal demonstration programs. For example, the federal government may cover some of the costs of planning and evaluation and even "insure" against adverse and unforeseen outcomes ("*Roadpricing: A Clash of Analysis and Politics,*" Thomas J. Higgins, Policy Analysis, Vol. 7, no. 1, Winter 1981).. The new ISTEA Congestion Pricing Pilot Program has authorized FHWA to carry out such demonstrations and set aside up to $150 million over the next six years.

- **Collateral Actions**: Success and acceptability of congestion pricing may depend substantially on collateral actions implemented with pricing. For instance, alternative transportation services may need to be expanded for those who are unwilling or unable to pay the congestion charges. New signalization may be necessary to handle through traffic diverted to ring roads and other facilities. Adversely affected groups (e.g., poor, residents of certain zones, some businesses) might need to be compensated in some manner to enroll their support for the program. For example, business taxes may need to be reduced during a test period. Fortunately, the congestion pricing approaches promise large new revenues to support collateral actions.

- **Political Support**: Lastly, implementation planning needs to focus on ways of nurturing political and constituency support. For example, many groups may benefit from road pricing, including transit users (presuming new transit service), neighborhoods which may experience less traffic and advocates for an improved environment. A successful implementation program will generate as much support from these groups as possible.

Despite its great promise to reduce traffic and enhance mobility, congestion pricing remains a largely untried strategy. Concerned about the lack of precedence and potential implementation and institutional hurdles, localities have been reluctant to embrace this approach in the past.

However, as traffic congestion worsens in the urban areas and spreads to suburban facilities, as the requirements to meet air quality goals take root, and as traditional sources of revenues for road and transit capacity expansion become increasingly scarce, congestion pricing may be viewed more favorably. In the future, congestion pricing may provide answers to some of the emerging mobility and fiscal problems in our cities.

Congestion pricing attempts in the past failed partly because the congestion levels at the time were not intolerable. Thus, while it could be shown that the programs would produce economic and revenue benefits, time savings per user trips would be small. Moreover, the technology for administering congestion charges was in an infant stage and not well tested. Most important, past attempts failed to give sufficient attention to implementation issues, in particular to concerns about adverse impacts on poor and on local businesses. Mitigating and compensatory actions were not well thought out.

As the urban traffic congestion has increased and spread, congestion pricing promises to generate much larger and visible savings in user trip time as well as larger economic benefits and revenues. Further, advances in AVI and related technologies promise to make road pricing administration and enforcement much more feasible and effective in the U.S. context. The legal picture also seems to be becoming more favorable. At the same time, localities face large shortfalls in funds for transportation.

Many localities which fail to meet federal air quality standards are also under extreme pressure from EPA to reduce automobile travel or face severe penalties under the new Clean Air Act.

All in all, congestion pricing may deserve renewed consideration in the U.S. Based on the promise and evidence to date, congestion pricing holds the promise to make a major contribution to the solution of urban and suburban congestion and air pollution problems. However, much will depend on the location, nature of its problems, and local goals and preferences. Further, success will require much careful planning, design, and analyses.

5.8 REFERENCES

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C. ALTERNATIVE WORK ARRANGEMENTS

Variable Work Hours/Compressed Work Weeks
Telecommuting

C.1 VARIABLE WORK HOURS/COMPRESSED WORK WEEKS

1.1 DESCRIPTION OF STRATEGY

Work hour policies established by employers govern the time period in which employees travel to and from work. Such policies influence not only the volume of employees traveling during peak traffic periods, but employee propensity to consider transit, carpooling and other alternatives to driving alone to work. Consequently, work hours management is thus another important component of travel demand management.

There are three types of variable work hours with potential application as demand management tools:

- Staggered work hours;
- Compressed work weeks; and
- Flextime.

Staggered hours are staged start work times set by employers. For example, employee start times might be set at 15-minute increments. The primary influence of this strategy is to spread peak traffic.

Compressed work weeks allow employees to work more hours in fewer days than the usual eight hour per day schedule. One common option is the "4/10, "where employees work 10-hour days over four days. The goal of this approach potentially is twofold: reduce vehicle miles of travel across the work week and encourage employees to arrive and/or depart outside normal daily peak periods.

Finally, *flextime* allows employees to set their own arrival and departure time within a band of time. The employee is required to arrive within a two- or three-hour band and leave eight hours later. This strategy potentially influences travel in two major ways. In congested areas, it may encourage employees to avoid most congested times, thereby spreading peak traffic. And where work hour differences within a company are a barrier to ridesharing, it can encourage rideshare candidates to coordinate arrivals and departures where they previously could not.

Employees and employers may find alternative work hours attractive not only to open up new transportation options, but also to improve the fit between work and family responsibilities. A four-day work week or flextime may make it easier for two-worker households to manage shopping, day care and other chores while still working forty hour weeks. Absenteeism, tardiness and turnover may be reduced by variable work hour programs in settings where workers need and want more flexibility in their schedules. For example, one company found flextime reduced sick time and personal leave an average of 3.5 days per year per employee and increased productivity by three percent ("*Off Work Early, Volume II, A Guide to Implementation,*" David W. Jones, Institute of Transportation Studies, February, 1983).

New work hour policies and programs will involve an array of private and public sector parties. Company management and corporate policies influence work hours. Employees, through their unions, also determine work hours. The public sector influences work hour policy in several ways. In terms of demand management, localities may encourage variable work hours through local demand management ordinances affecting employers. Likewise, states and air quality districts may require attention to variable work hours in local regulations and rules. Finally, federal labor legislation (and sometimes state legislation) sets certain parameters within which any work hour program, variable or not, must operate.

1.2 NATURE OF EFFECTIVENESS

Variable work hours support demand management in two ways:

- Compared to regular employee work hours, e.g., 9 a.m. to 5 p.m., variable work hours spread arrival and departure times and thereby spread peak period traffic.
- Depending on the type of variable work hours implemented, employees are encouraged to consider ridesharing and transit use.

Regarding the first point, given the choice of traveling in congested traffic and arriving during the peak period or arriving earlier or later than the peak, many employees will choose to arrive before the peak period (see examples 1.4). Regarding the second point, where employees resist transit use in part because transit schedules or capacities do not match well with work hours, a change in required arrival or departure times may boost transit use. Under flextime, for example, an employee might arrive early and ride transit before it is so crowded as to require standing. Likewise, more employees might be able to carpool if there is some flexibility in required arrival times. Two employees now living near one another but working different schedules might be able to carpool if they could coordinate their arrival and departure under a new flextime or a 4/10 schedule.

Work hour strategies may not always support ridesharing and transit use. In particular, some experience and research (see examples) suggests flextime is sometimes associated with less ridesharing, not more. More research is needed to determine why this is the case. It may be that flextime interferes with rideshare arrangements already in place and dependent on fixed work schedules. For example, three commuters arriving at 8:00 a.m. may successfully carpool under fixed hours, but one or more may opt out of carpooling if they are allowed to arrive at different times. It may also be the case that, by having the freedom to travel outside the most congested portion of the peak period, the traveler loses the incentive to rideshare or use transit. Compressed work weeks do not seem to suffer from the same problem, as the examples suggest. In fact, there is some evidence suggesting compressed work weeks even may support ridesharing. Unfortunately, there is no evidence on how staggered work hours affect ridesharing, though one recent study indicates the strategy made it more difficult for program participants to use express bus service.

1.3 APPLICATION SETTING

Variable work hours have been implemented in both the public and private sector, and among a variety of work forces:

- ***Flextime:*** most applicable to offices and among administrative and information workers; less application to shift workers and assembly lines, or where there is need for continuous communication between workers.

- ***Compressed work weeks:*** applicable to office and administrative functions, especially governmental agencies; perhaps most applicable to line and piece manufacturing processes.

- ***Staggered hours:*** applicable to offices and piece manufacturing, but not applicable to line manufacturing where workers are highly interdependent.

Variable work hours operate where a large number of employees are affected, and where the associated traffic is concentrated rather than spread out. For example, flextime implemented by a large industry or government agency may considerably reduce traffic on streets and highways in the immediate vicinity of the agency or plant. Likewise, peak loading on transit facilities might be reduced.

Because one or another variable work hour strategy may be applicable to various industries, variable work hours should not be considered only in urban settings. In fact, one of the more successful examples of employers shifting employee arrival times is in Pleasanton, California, a suburb in the San Francisco Bay area. Here, many large and small employers have shifted employee arrival times in response to a City trip reduction ordinance aimed at reducing peak period travel.

More important than location may be supporting services. In particular, the benefits of work hour strategies in encouraging transit and carpool use depend on the availability of transit options and rideshare matching and monitoring. For example, where transit service is frequent and with available capacity at the "shoulders" of the peak, some employees will find it a more attractive alternative once work hour schedules are less of a barrier to using transit.

1.4 EXAMPLES

Few evaluations of variable work hours programs have been undertaken. However, there are a sufficient number of case studies to suggest the direction of impacts on travel and mode share, the range of impacts and certain important cautions.

TIMING OF TRIPS

The first important impact of variable work hours is on the *time of employee travel.* As discussed previously, one of the most important potential effects of variable work hours programs is reducing the volume during peak periods.

Compressed Work Week: A carefully controlled experiment among federal employees in Denver showed this strategy can both flatten the peak arrival volume and shift when the peak occurs. Participants arrived one hour earlier on average than before the program, and departed about one hour later. The program flattened the peak in arrival times. The maximum percentage of total arrivals in a half hour period was reduced from 56 to 42 percent. The maximum half hour percentage of total departures also was flattened from 47 to 34 percent. Of course, the influence of such a shift depends on how many employees participate in the program. In this test case, the participation within federal agencies exposed to the program was 65 percent. About 9,000 federal employees in 42 agencies participated. The most popular forms of compressed work week were the four day work week with ten hour days and a five/four-nine plan. (*"Transportation Related Impacts of Compressed Workweek: The Denver Experiment,"* Terry Atherton, et. al., Transportation Research Record No. 845, 1982).

Flextime: This strategy appears to have a positive effect on time of arrival. For example, one test in San Francisco showed at least half of the participants arriving to work 30 or more minutes earlier than before flextime. Many arrived at work at 7:00 a.m. By traveling before the main peak period, those arriving by car and/or carpool saved an average of nine minutes each trip, or an hour and a half for two-way commuting each week. Over 60 percent reported they encountered "much less congestion" on their way to work. In the test, about 6,000 employees participated in the flextime experiment across 23 companies. ("*Off Work Early,*" by David Jones, Institute of Transportation Studies, University of California at Berkeley, February, 1983; also, *"Flex-Time: A Voluntary Approach,"* ITS Review, Vol 6, No. 2, February, 1983). At Bishop Ranch in California, flextime policies appear to be successful in shifting employee arrival times to earlier periods. A survey of 14,800 employees between 1988 and 1990 showed the percent of employees starting work before 7:00 a.m. increased from 8 to 17 percent, and the percent starting work after 9:00 a.m. increased from 1 to 9 percent. Departure peaking also has been reduced. The percentage of workers leaving before 4:00 p.m. increased from 12 to 17 percent. The employer flextime programs were instituted as part of a broad demand management program for the area, as well as a local trip reduction ordinance encouraging reduction of peak hour vehicle trips (*"Bishop Ranch 1990 Transportation Survey,"* Steve Beroldo, Rides for the Bay Area, December 1990).

Staggered hours: One recent evaluation of staggered hours in downtown Honolulu found statistically significant reductions in peak period travel time due to spreading of the peak. Travel time was measured from a "floating car," meaning reductions in actual travel time were measured along specific commute routes. Reductions were up to 18 percent depending on the route, or up to seven minutes in the commute. The study makes clear there are winners and losers under staggered hours. Those making early departures saved the most in travel time. Those shifting to a later arrival time actually lost travel time, because they moved into the new peak period. About 3,500 employees of the 7,100 employees in the Civic Center participated in the project. Participation in the project was mandatory for all public employees, though private sector participation was voluntary. About 18 major corporations participated. Overall, about 11,000 employees participated, or about 18 percent of the downtown work force. (*"Staggered Work Hours for Traffic Management: A Case Study,"* Genevieve Giuliano, Thomas Golob, paper before the 69th meeting of the Transportation Research Board, January, 1990).

MODE OF TRAVEL

A second important impact of variable work hours is on *mode of travel*. Variable work hour programs could conceivably break up carpools or make transit use more difficult depending on carpool arrangements and transit schedules prior to and after the work hour program was instituted. Some evaluations have addressed this subject:

Compressed Work Weeks: In the case of Federal employees in Denver, evaluations suggest the strategy had no adverse effects on ridesharing and transit. Denver showed VMT reductions for work and non-work travel among participating employees of 15 percent, with no adverse impacts on ridesharing or transit use. Given the large number of employees participating, this reduction translates into a fairly large reduction in VMT for Denver federal employees taken as a whole: 5.6 percent. Another recent study of compressed work weeks suggests it was associated with a decline in solo driving, from 82 percent to 77 percent (*"The Effects of Variable Work*

Hour Programs on Ridesharing and Organizational Effectiveness, A Case Study: The County of Ventura," Alyssa Freas, Stuart Anderson, a paper before the Transportation Research Board, January 1991).

Flextime: Some studies show flextime is associated with increased ridesharing, but not in other cases. RIDES, the regional rideshare agency in the San Francisco Bay Area, has found the placement rate among its rideshare applicants on flextime to be 30 percent compared to 16 percent for applicants not on flextime ("*1988 Database Survey, RIDES For Bay Area Commuters, Inc.,*" David Burch, San Francisco, California, December 1988). Another study suggests only about nine percent of workers changed modes due to flextime, and among these, "there was a small net change in favor of ridesharing and public transport ("*Behavioral Impacts of Flexible Working Hours,*" M. Ott, H. Slavin, Transportation Research Record, NO. 767, 1980). Employee surveys in Pleasanton, California, however suggested only 7.6 percent of Pleasanton workers under flextime used ridesharing, compared to 11.4 percent of the entire Pleasanton work force ("*America's Suburban Centers - A Study of the Land Use Transportation Link,*" Robert Cervero, January 1988, Op. Cit., p. 128.) Another study of flextime introduced at the Tennessee Valley Authority suggests a small loss (about two percent) in vanpool ridership due to the flextime program. Vanpoolers adjusted their schedules to meet rider preferences for earlier arrival times. However, bus ridership fell considerably (21 percent) because bus schedules were not changed in a similar way. The case shows the importance of coordinating alternative mode services with work hour programs and employee preferences for arrival and departure times ("*Impact of Flextime on an Employer-Based Rideshare Program, Case Study of the Tennessee Valley Authority, Knoxville, Tennessee,*" Frederick J. Wegmann, Stanley Stokey, Paper presented before the 1980 Transportation Research Board Meeting). Another study suggests both the importance of coordinating express bus service with variable work hours, and a method for doing so in the case of staggered hours ("*Descriptive Summary of the Bus Express Employee Program: Demonstration of Employment Center Bus Service,*" Southern California Rapid Transit District, September, 1980).

NON-WORK TRIP MAKING

A third important impact of variable work hours programs has only recently been recognized. With a shift in work hours, usually to earlier arrival and departure times, more time is available for *non-work tripmaking*. Therefore, the overall impact of variable work hours programs on VMT could be negligible or even opposite to that intended. As noted above, the Denver study indicated that such was not the case for federal employees. However, insufficient evidence has been collected to state definitively that variable work hours programs will significantly reduce VMT overall.

1.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

As the examples suggest, there is much variation in the expected traffic impacts of variable work hours. Much depends on the type of work hour strategy, whether mode choice is affected, as well as time of travel and the nature of the local congestion problem. The possible results of implementing a variable work hours program are summarized here:

- The most probable effect of a variable work hours program is earlier arrivals and departures of participants, with a flattening in peak period traffic. The magnitude of the peak flattening may be quite substantial. The results of the Denver experiment with compressed work weeks showed a 14 percent decline in the maximum percentage of total arrivals in a half hour period, and a 13 percent decline in the maximum half hour percentage of total departures.

  It should be noted that neither flextime nor staggered work hours measures remove vehicle trips or vehicle miles traveled from the daily travel inventory, but generally only shift their timing. This is acceptable for some TDM situations, but not a solution for others, e.g., air quality problems.

- Compressed work weeks may reduce vehicle miles of travel, depending on number of commute days and mode of travel. Compressed work weeks appear to reduce not just work trips, but total trips ("*Case Study on Impact of 4/40 Compressed Work Week Program on Trip Reduction,*" Transportation Research Record No. 1346, 1992). Case studies suggest VMT reductions of 15 percent. The reason for the VMT reduction is simply the fact that commuters work fewer days per month, and non-work trips do not offset the reductions in work trips. For flextime and staggered work hours, effects on VMT are not so clear cut. All depends on whether the mode of travel is affected. The evidence suggests flextime may encourage transit use where service is sufficiently frequent and available before peak periods when flextime participants prefer to travel. Good transit service is probably the reason for the boost in transit ridership under the San Francisco flextime experiment. However, where flextime is introduced without good transit service off peak, or where the service is not adjusted to allow for commuters wanting to travel in earlier times, then transit ridership may well decline. The Tennessee Valley Authority case study provides one such instance.

1.6 COST EFFECTIVENESS

The literature does not document costs of implementing variable work hour programs. Main cost items include labor time to plan and set up the program, and possible increased utility and security costs associated with opening an office earlier and keeping it open later than usual.

While the literature does not quantify costs, one source suggests they are minor in comparison to potential benefits in reduced trip making and increased productivity. A study of flextime indicated voluntary increases in employee work hours, reduced tardiness and reduced work hours missed due to inclement weather ("*Behavioral Impacts of Flexible Working Hours,*" Marian Ott, Howard Slavin and Donald Ward, Transportation Research Record No. 767). Another study of firms in Lower Manhattan suggested 15 percent involved in staggered work hours reported communications problems, but said these costs were balanced by other efficiency gains in increased employee punctuality ("*Staggered Work Hours in Manhattan,*" *Traffic Engineering and Control,* O'Malley, B. and C.S. Selinger, Volume 14, No. 9, January, 1973).

Costs

The best way to illustrate the possible cost effectiveness of a variable work hours program is to estimate the cost of instituting a variable work hour program in a medium size company. Suppose a program is implemented in a company of 2,000 employees and results in a total 15 percent VMT reduction among program participants, as in the Denver experiment referenced above. Suppose further that the program increases some information and transaction costs within the firm or between the firm and other businesses, but the costs are balanced by reductions in employee tardiness and gains in productivity. Consequently, the net program costs are those incurred in setting up the program and operating building facilities for longer hours. Assume a mid-level manager works 40 percent of the time over one year to create the program, for an initial investment of $25,000. Assume other personnel costs for meetings and policy changes incur about the same costs, for a total investment of $50,000 in round numbers. Assume extra utility and security costs of $1,500 per month or $18,000 per year. Assume the company amortizes these costs over thirty years and uses a 10 percent discount rate. The present value of the total investment given these assumptions is $219,684.

Benefits

The effectiveness and savings of the program all depend on what proportion of employees begin variable work hours and their respective before and after driving habits. The Denver experiment gives clues on both points. In the experiment, 65 percent of employees exposed to the program changed work hours, and among this group the total VMT reduction was 15 percent. The high participation rate is perhaps unique to government employees. Suppose only 15 percent of employees in the example firm begin the variable work hour program and reduce their work trip VMT by 7 percent, about half of the reduction in VMT in the Denver experiment where both work and non-work trip reductions were counted. Thus, among the 2,000 employees in the example firm, 300 participate and reduce their VMT by seven percent.

With this VMT reduction, we can estimate trip reduction. Presuming there are about 90 vehicle trips per 100 employees (allowing for some use of transit, carpooling, walking), then the 300 employees make 270 vehicle trips to work. If work trips are 20 miles in length, the 300 employees generate 5,400 vehicle miles and a seven percent reduction is a savings of 378 miles, or the equivalent of 19 vehicle work trips.

Finally, from trip reduction, we can derive cost effectiveness. Presume a reduced trip saves at least operating and maintenance costs at $0.30 per mile. Then the savings of 378 miles daily represents $2,268 per month and $27,216 per year.

COST EFFECTIVENESS

Is the "investment" in the variable work hour program worth the initial cost? As with any investment, it is worth it if the payback in savings accrues in a reasonable amount of time. When do the accumulated savings "payback" the costs? It is the point where the present value of one-time and ongoing costs equal the present value of ongoing savings in vehicle operating costs. Table 1-1 shows the program pays for itself in a little over six years.

Table 1-1
Cost Savings
from a Variable Work Hour Program

(1) Costs	
Initial Staff Time	$ 50,000
Present Value of Utility Costs (30 years @ 10%)	$169,684
Total Present Value of Costs	$219,684
(2) Savings	
Vehicle Operating Cost Savings (@ $0.30 per mile)	$ 27,216
(3) Break Even Point	
(Present Value of Savings = Present Value Costs @ 10%	**= 6.21 years**

1.7 IMPLEMENTATION ISSUES

Careful planning is needed to start any variable work hours program. Steps include assessing managers in various departments, possible conflicts with the need to interact with clients and customers, and needed changes in company policies. As the cost assessment suggests, it also is important to estimate the need for changes in security coverage and settings in building heating, cooling and lighting. Procedures and costs associated with these changes need to be assessed and compared with benefits in vehicle trip reduction. Finally, an evaluation system should be set up including a monitoring committee and a regular assessment survey of employees and managers. Some important steps in the implementation of variable work hours within participating companies and organizations include:

- Meetings with each level in an organization to spell out the proposal, gain feedback, assess feasibility and modify plans.

- Modification of work hour policies and union agreements as needed to accommodate the designed program. Some key labor issues include the definition of overtime in a flexible schedule, which employees will and will not qualify for variable work hour consideration, method of recording and tracking hours worked.

- Development of supervisor information guides with individual counseling sessions. For example, how to insure telephone coverage (rotating coverage by secretaries); how to insure check abuse (remove flextime privilege for offenders).

- Pilot program implementation for six months with assessment survey to evaluate worker and supervisor reactions. Survey should address issues of commute, personal control over time, communications with supervisors, morale, absenteeism, turnover, work flow, service quality and customer perceptions.

Variable work hours may involve some implementation hurdles. Sometimes labor union agreements will restrict the hours employees work. Any change may require formal meeting and negotiating. Management may resist flextime believing it reduces flexibility to schedule meetings or inhibits responsiveness to clients and customers. One study of four-day workweeks suggests managers believed communication between departments and between agencies or firms may be adversely effected. ("*The Impacts of Feasible Staggered Work Hours and Compressed Work Week Policies on Highway Networks, Transportation Economics, Organizations and Employees,*" Anis Tannir, New York State Department of Transportation, August, 1977.) Another survey of State Departments of Transportation found employees generally favored alternative work hours, but management expressed concern about employee supervision ("*State Transportation Agency Use of Non-Traditional Work Schedules,*" V.W. Korf, R. Pauley, Transportation Research News, No. 95, 1981).

As programs in Hawaii, Denver and San Francisco suggest, large numbers of employers can be involved in variable work hour programs even without regulation. Aggressive campaigns initiated by the public and private sector in employment centers may be sufficient to attract considerable participation. However, variable work hours also can be encouraged through trip reduction ordinances, air quality regulations and other policies. These regulations can require employers to consider variable work hours as part of demand management programs, and to implement work hour changes where feasible and beneficial.

City, county and state governments also might consider mandatory variable work hour programs for their employees, especially where large government centers contribute to local traffic and congestion problems. Care is needed in designing such programs, as the case of mandatory programs for government employees in Honolulu suggests. Those obliged to shift to a later arrival time under the staggered work hour program experienced greater travel time compared to their previous situation, leading to considerable resentment and dissatisfaction. In the experiment, almost all private sector managers reported the same or better level of employee morale during the project under their voluntary program. In contrast, city-county managers reported worse or much worse employee morale during their mandatory project. Probably the best approach is to require agencies and departments to devise the best work hour system for their particular functions and public interaction needs. Furthermore, employees probably will prefer compressed work weeks and flextime to staggered work hours.

Finally, state policies and legislation may need revision in some cases to encourage variable work hours. Many states have fair labor acts and standards which limit the maximum number of hours worked without compensation for overtime. Sometimes, the legislation requires work in excess of 40 hours per week to be compensated at some multiple of regular hourly rates. While this is not a barrier to flextime, it could present implementation issues under compressed work week programs allowing more than 40 work hours in certain weeks. Less common is legislation setting maximum requirements on a daily rather than weekly basis. State labor legislation of this kind would have to be changed to allow any form of compressed work week.

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C.2 TELECOMMUTING

2.1 DESCRIPTION OF STRATEGY

Telecommuting is an approach for reducing home-to-work trips by allowing employees to work-at-home. Employees may be linked to the work place by computer and modem, or simply may take work home requiring no computer. Telecommuting employees usually work at home one to several days per week but generally report to a central office location on the remaining days. A related option, telework centers allows employees to work at a satellite work center (run by single employers) or neighborhood work centers (run by multiple employers). The centers usually are equipped with computers and modems and connected to a main office.

Telecommuting is a growing phenomenon. There are about 4.4 million telecommuters in the United States, a figure that has grown about 20 percent per year since 1988. The growth trend is spurred by the nature of the economy and by technology advances. In 1950, only 17 percent of U.S. workers were in information or service businesses such as sales, public relations, personnel, banking, health care and publishing. By 1980, over 50 percent of workers held information and service-related positions. With proper equipment, many functions associated with these positions can be done from the home or remote locations. Laptop or personal computers can be used to dial into host computers to retrieve information, update files and relay products. Recently, AT&T announced software for automatic call distributors allowing companies to route incoming calls and data to customer service agents working at home, allowing companies to recruit agents who need to stay at home to care for a small child or elderly person. For telecommuters geographically dispersed, companies can arrange to provide dial-up or virtual services. For telecommuters concentrated in a single locale, companies can lease a dedicated line to a central neighborhood center. There still are some technological barriers. For example, there is no easy way to tie a telecommuter into a company's electronic mail and voice mail systems. Forwarding calls to another employee if the telecommuter isn't home also is a problem (*"Users Need to Adopt Telecommuting Plans,"* Network World, March 18, 1991).

Telecommuting is an important element of employer demand management programs. Not only can the strategy reduce the number of work trips for those working at home and/or their length for those working at satellite centers, it may dovetail with other employer objectives including improved morale and productivity. For example, in a pilot project at AT&T and state agencies in Phoenix, Arizona, 80 percent of supervisors of telecommuters said telecommuting increased employee productivity; 76 percent said telecommuting improved employee morale; 90 percent said the telecommuting program should be expanded (*"Phoenix Telecommuting Project Doing*

Very Well," Urban Transportation Monitor, May 10, 1991). In a State of Hawaii pilot program discussed later as examples, 80 percent of telecommuters reported an increase in work productivity. The majority of supervisors said productivity increased. Thus, telecommuting is a demand management strategy likely to be attractive to employees and managers.

Because the strategy is new, it is difficult to estimate potential benefits. Much depends on future growth of telecommuting, the mix of industries in the future and unforeseen technology advances. One forecast estimates $23 billion could be saved annually in transportation, environmental and energy costs if there is a 10 to 20 percent increase in activities done through telecommuting instead of through physical transportation improvements (*Network World,* Op. Cit).

2.2 NATURE OF EFFECTIVENESS

Telecommuting potentially affects employers, employees and employee household members. Each party may alter travel patterns as a result of telecommuting. Travel may be directly or indirectly affected depending on to what extent telecommuting affects work and non-work trips, and the mode choice of affected parties.

- *Work Trips:* Telecommuters may make fewer trips or fewer and shorter trips, depending on whether they telecommute from home or from a satellite work center. Telecommuting also may influence mode choice. Telecommuters may switch from solo driving to walking, cycling or transit to access neighborhood or satellite centers closer to home than their main office. Or, they may switch from carpools and transit to solo driving, cycling or transit.

- *Non-Work Trips:* Telecommuting may affect non-work trips. For instance, telecommuters or their family members may make more shopping trips as a result of having flexibility in work time or a vehicle at home normally parked at work.

How telecommuting affects work and non-work trips in any particular setting is a function of many variables. Some home workers may make mid-day shopping trips normally made as part of their usual work trip. Thus, while the trip is not made during congested peak times, it does entail a cold start and is possibly longer than usual. Teenagers coming home from school may have access to a vehicle in the afternoon and therefore may make some vehicle trips not previously made.

For the telecommuter going to satellite or residential centers, all depends on the location of the center relative to home. If the neighborhood center is close, the telecommuter may walk or cycle to work, or even use transit. If the center is not close, because of the outlying locations that would be served, the telecommuter may be highly inclined to drive. Their trip length may be shorter than usual, but they may not use an alternative mode such as transit or carpooling as they might normally do for their work trip.

Evidence to date, as the examples suggest, indicates telecommuting may increase non-work trips somewhat, but not enough to outweigh work trip reductions.

2.3 APPLICATION SETTING

The prospects for telecommuting depend on the setting in which it is applied. Important considerations include the type of employer work force and characteristics of the industry. Information industries such as accounting, data processing, programming and engineering design are more amenable to telecommuting than production lines, construction or sales. At Pacific Bell, for example, a pioneer in telecommuting, most of the 2,000 telecommuters are financial specialists who gather and analyze lots of data (*Network World,* Op. Cit.) Other examples:

- Heights Information Technology Service subcontracts work to data processing professionals who work at home full- or part-time;
- Blue Cross employs 16 data entry personnel who work at home;
- Control Data uses 100 full- or part-time computer programmers working from homes; and
- Hughes Aircraft set up a satellite office away from its main plant as a work site for its artificial intelligence experts (*"Telecommuting Phenomenon: Overview and Evaluation,"* SCAG, March, 1985).

In today's workforce of information workers, telecommuting may have significant application. One study suggests 16 percent of VMT for all trips now may be amenable to telecommunications. Another finds 40 percent of all work trips may be substituted (*"The Telecommuting Phenomenon: Overview and Evaluation,"* SCAG, March 1989).

Also important to the application of telecommuting are employer policies. The number of employees eligible to participate in a telecommuting program, the extent of encouragement to participate, and which days telecommuting is allowed, all affect the potential application of the strategy.

Because telecommuting is a relatively new demand management strategy, its first application may be as a pilot project. For example, state governments in California, Washington and Hawaii are testing telecommunications within certain agencies and departments. The Federal Office of Personnel Management has started a pilot program projected to involve 30 federal agencies around the U.S. Once proven to the satisfaction of management, the governments will develop new work hour and work at home policies to encourage and formalize telecommuting within state agencies.

Telecommuting has potential application in urban, rural and suburban settings. Unlike other demand management strategies, the success of home-based telecommuting is not dependent on the quality of alternative modes. Thus, the strategy has application even where transit or rideshare services are not substantial. However, the quality of alternative mode services is an important consideration for residential and satellite telecommuters. To maximize the prospects of these commuters using alternative modes, satellite centers should be served by transit, bike lanes, and ridematching services.

2.4 EXAMPLES

Because telecommuting is a new concept, good evaluations are not numerous. However, there are a sufficient number of case studies to suggest important impacts on trip making.

The first important effect of telecommuting is on the number of work trips made. Next is the issue of non-work trip impacts. Finally, there is the question of any effects on mode of travel.

WORK TRIPS

Examples of telecommuting suggest significant impacts on work trips:

- In a test among employees at the Southern California Association of Governments (SCAG), telecommuting reduced person trip miles due to work trips avoided and shorter trips to satellite centers. The net person trip reduction was 46 miles for each telecommute occasion. Allowing for the usual mode of travel for telecommuters (solo, rideshare, transit, etc.), 31 vehicle miles of travel were saved per telecommute. Fourteen percent of employees at the agency participated in the experiment beginning in June, 1986. Average participation was once every nine days. Most worked from home. One worked at a satellite work center. Not only were travel impacts positive, but impacts on productivity were positive. Management raised few concerns about lack of availability for meetings and communication with staff. ("*Evaluation Report,* *Telecommuting Pilot Project,*" Southern California Association of Governments, August 1988.)

- In preliminary findings among State of California telecommuters, work trip rates decreased 30 percent, from 0.9 trips per day to 0.63, compared to a control group where work trip rates did not change. In the project, workers telecommuted one to two days per week. The project involved over 400 State employees across 13 agencies, including both treatment and controls. Travel diaries were used to track travel impacts. (*"Telecommuting as a Transportation Planning Measure: Initial Results of State of California Pilot Project,"* R. Kitamura, et. al., a paper before the Transportation Research Board, 69th Annual Meeting, January, 1989).

- A recent evaluation of the State of Hawaii satellite telecommute demonstration project found 93 percent of employees reported a reduced number of work trips and an average drop in fuel consumed of 29 percent (from 18 to 12.7 gallons). Travel time savings were 7.4 hours per week, or 385 hours per year. In the experiment, the Hawaii State Department of Transportation established a telework center in Mililani, Oahu, located twenty miles from downtown Honolulu. Seventeen employees -- seven from six different Hawaii state agencies and ten from five private sector companies--participated in the experiment. (*"Evaluation of the Hawaii Telework Center Demonstration Project,"* Department of Transportation, State of Hawaii, September, 1990).

NON-WORK TRIPS

Effects on non-work trips are mixed, but not so negative as to outweigh work trip reductions:

- The study cited of SCAG employees shows some increase in non-work trips due to telecommuting. Under worst case assumptions, the vehicle miles created were 14 percent of the miles saved. Thus, instead of 31 miles of travel saved per telecommute, only 26 miles were saved.

- Preliminary findings from the study of California state employees involved in telecommuting showed no increase in non-work trips by telecommuters compared to controls (*Kitamura et al.,* 1989b). Furthermore, there was a reduction in non-work trips for other household members. Person trips per day for non-work trips fell from 3.6 to 2.3, a 35 percent drop. In this one experiment, it seems telecommuting favorably influenced overall household trip making.

MODE OF TRAVEL

There is no information yet on telecommuting affecting mode of travel. In the study of SCAG employees, 19 percent shared a ride before telecommuting. Depending on the number of carpoolers switching to telecommuting, carpools may simply rearrange, continue with less occupancy or terminate (either temporarily or permanently).

2.5 TRAVEL AND TRAFFIC IMPACT POTENTIAL

The examples suggest significant travel and traffic impacts from telecommuting. Generally, the main potential impacts include:

- Reduced vehicle work trips in the case of home work location, and reduced vehicle trips or trip lengths in the case of satellite centers.
- Potential increase in non-work trips, though evidence to date suggests no increases or small increases in such trips compared to decreased work trips.
- Possible changes in mode of travel for work trips, whether from solo driving to walking and cycling for satellite centers, or from carpooling and transit to solo driving for home-based telecommuting.

Of course the specific traffic impacts of trip reduction due to telecommuting depend on the location of main offices, home and satellite work sites. The impacts also depend on how often and what week days workers telecommute. In the best case, telecommuter work trips are removed from congested highways and arterials leading to and from main offices. No work trips are made on the telecommute day, or any work trips to satellite centers are made on uncongested roads. And, telecommuting takes place several days per week. In the worst case, telecommuting removes work trips from roads not congested, or breaks up carpools, or occurs only on days (e.g., Fridays or Mondays) when traffic is at its lightest, or adds work trips to satellite centers along congested roads. Only careful assessment and continuous evaluation in each work setting will determine the degree to which the best and worst cases apply.

2.6 COST EFFECTIVENESS

The costs of telecommuting include personnel training, telecommunications installation and operating charges, computer and/or modem purchase and maintenance, possible furniture purchase, insurance and the administrative costs of administering a program. Telecommuting costs may also include an increase in heating, ventilation and cooling at telecommuter households. There also may be indirect costs associated with less availability of employees for meetings on short notice, the need for changes in managerial style and new procedures insuring data security. Some of these costs are borne by the employer and some are not. For example, some employers provide personal computers for their telecommuters while others do not.

COSTS

Studies address these costs. One study of costs and benefits of telecommuting for 500 City of Los Angeles employees estimates two-year demonstration costs at $970,000, including additional phone charges, administrative costs, and new equipment and software. Cost per year per participant therefore are $970, presuming equipment costs are allocated over two years instead of amortized over a longer period. Indirect costs were not estimated. Benefits in office space savings and improved employee productivity were estimated to exceed costs (*"Telecommunity, City of Los Angeles Telecommuting Project,"* Volume 5, No. 2, September/October, 1989, Southern California Association of Governments). Another study estimates first year costs at $533 per participant, declining to $258 per year thereafter (Jack Nilles, Walter Siembab, *"Telecommuting and Vanpooling: Cost and Benefit Comparisons,"* unpublished paper submitted to Transportation Journal, June 1991). The later study assumes no need for additional computers and no increase in building heating costs.

Obviously, cost estimates vary. What's realistic? Assuming some new computer and modem equipment may be necessary and some added utility costs at the home end, the lower annual cost estimate may not be realistic. Allowing for some amortized equipment costs and added utility costs, a steady-state direct cost of $350 per employee per year could be aimed at. Finally, there are indirect costs, as noted above, associated with less availability of employees for meetings on short notice, the need for changes in managerial style and new procedures insuring data security.

For simplicity, it should be assumed that these costs are balanced by the indirect benefits of decreased employee sick leave usage, decreased employee turnover, increased productivity and office space savings. This may be a conservative assumption, as these benefits were estimated not to balance but exceed many program costs (including administrative costs) in the City of Los Angeles study.

COST EFFECTIVENESS

Assuming indirect costs and benefits balance, we may estimate how direct costs compare with the benefits of reduced trips. At a cost of $350 per participating employee per year, daily costs are $1.34 (based on 261 days per year). According to the State of California data, work trips per participating employee declined from .9 per day to 0.63, or 0.27 trips per day. Cost per unit trip reduced, then, is $4.97.

Presuming an average trip is 20 miles in length, and operating and maintenance costs are $0.30 per mile, the investment of $4.97 more than saves the Operating and Maintenance (O&M) costs of $6.00, let alone external costs of pollution and congestion.

2.7 IMPLEMENTATION ISSUES

To maximize the potential effectiveness of telecommuting as a demand management strategy, localities should take several steps:

- Insure telecommuting is encouraged in trip reduction ordinances, air quality regulations and any legislation pertaining to demand management at employment sites. In some cases, these policy instruments are not structured to encourage telecommuting. For example, often trip reduction ordinances specify goals aimed only at increasing average vehicle ridership. Such goals will not encourage telecommuting unless specific credits are developed for telecommuters. A better goal for purposes of encouraging telecommuting is overall trip reduction measured across a typical week. This goal insures reduced trip making on the part of telecommuters is counted toward the ordinance or regulation goal.

- Encourage demonstrations in both the public and private sector. Telecommuting is still a relatively new demand management strategy. Most states and local governments begin telecommuting through carefully evaluated pilot programs. These pilots should be encouraged and well publicized. If a joint public-private program is launched, the private sector may not only join in the demonstration, but donate equipment and services, especially for satellite centers. This was the case in the Hawaii demonstration discussed above.

- Ease barriers to telecommuting. Localities can develop model employee-employer agreements to deal with barriers. Such models should alleviate concerns about equipment liability, theft or damage and eligibility for worker's compensation. Companies should be cautioned to avoid putting telecommuters on a contractor basis or by requiring them to buy their own equipment and provide insurance coverage. Union and labor groups should be consulted in the design of pilots to guard against their resistance. The AFL-CIO in 1983 passed a resolution calling for the Department of Labor to ban computer homework except for the handicapped. The Service Employees International Union banned telecommuting in 1982 for its clerical and health care workers. However, if employees are interested in telecommuting, union concerns can be moderated. Finally, localities can modify local zoning codes which prohibit or discourage work at home arrangements. Some of these laws arose in the 1940's out of concern for "sweatshops" and "cottage industries" (Southern California Association of Governments, *"The Telecommuting Phenomenon: Overview and Evaluation,"* March 1985).

Localities also should ensure telecommute programs are designed to have the best possible chances at success. Successful programs should:

- Establish telecommuting as a voluntary arrangement between supervisor and employee, not an entitlement or employee benefit. Either party may terminate the arrangement with notice.

- Measure job performance by results under clearly defined tasks and deliverables.

- Ensure that telecommuters working at home agree to secure proprietary information.

- Gain agreement between the employer and telecommuter on ownership and use of equipment. One option is for the company to provide the equipment (e.g. computer, modem, printer, access line) and retain all ownership rights to it. Another is for the employee to use his or her own equipment and receive some compensation. In any case, costs for employee business calls must be compensated.

- Work out utility cost implications. Most telecommute programs do not compensate employees for any additional utility expenses associated with work at home. Employers and employees need to address and negotiate this issue. The usual rationale for not compensating these expenses is that the benefits of working at home offset the incremental increase in utility costs.

- Ensure telecommuters are covered under Workers' Compensation for job-related accidents occurring when the employee is working at home. Employees work in a designated work space free from hazards. The employer, with reasonable notice, may make on-site visits to determine the site is safe.

- Establish liability. Usually, the employee remains liable for injuries to third parties and or members of the employee's family on the employee's premises.

- Help employees understand tax implications relating to the home work space. Generally, IRS allows a deduction for home offices provided the employees use it for the convenience of the employer. It is not necessary that the employer require work at home as a condition of employment. However, the designated place of work must be used exclusively for work purposes.

- Spell out all arrangements in a Telecommuting Agreement. Any violation of the rules may result in termination of the telecommuting arrangement.

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Implementing Effective Travel Demand Management Measures:
Inventory of Measures and Synthesis of Experience

PART III: SYNTHESIS OF FINDINGS

III. SYNTHESIS OF FINDINGS

3.1 OVERVIEW

The purpose of this chapter is to begin to integrate the information on individual TDM measures and experience presented in the previous chapter to a level that is more useable by the practitioner who is concerned about packaging and implementation.

The previous section, Part II, provided a catalogue and detailed discussion of 11 primary TDM actions. The intent was to provide the reader with a comprehensive *reference guide* on each of these actions, in order to understand its nature and application at an *individual* level.

This section, Part III, begins the ***integration process***, leading toward building of these actions into comprehensive programs. The following topics are covered in this presentation:

Synthesis of Empirical Evidence (Section 3.2): Summarizes the evidence on experience to date with TDM programs, showing the range of impact potential and factors which have led to successful -- or unsuccessful -- implementations.

Projecting the Effectiveness of TDM with Analytic Tools (Section 3.3): Indicates why the empirical evidence, though important, is insufficient when attempting to do TDM planning and program development, and introduces the reader to an analytical tool for gauging impact. Through a staged application of this analytic tool, the reader is provided with tables and graphs that reveal the range of impacts that are achievable with each of the individual TDM strategies across different levels of stringency and in different implementation environments. An initial sense of what types of packaging of strategies will lead to most effective programs is provided.

Cost Effectiveness (Section 3.4): Indicates the extent to which TDM programs are effective in an economic sense to three different constituencies: society at large (taxpayers); employers (private sector); and individual travelers.

Implementation Considerations (Section 3.5): Provides guidance on how to approach the implementation process, a helpful system of classification of "stringency of implementation effort" versus "level of need", and offers a menu of implementation mechanisms for consideration.

3.2 SYNTHESIS OF EMPIRICAL FINDINGS

3.2.1. Overview

There is a growing body of evidence that TDM measures, when properly applied, can have a profound impact on vehicle trip making and traffic levels. Research in this and other studies have been able to solidify theoretical beliefs that travelers behave rationally in light of their alternatives, and if the relative benefits of those alternatives are changed, behavior will also change. There is much more certainty and predictability to these relationships than has been understood or accepted to date.

What is important to underscore in understanding the impact potential of TDM is that **substance** is vitally more important than **appearance**. TDM programs often start off with elements that are judged to be most palatable to the target audience, in order to encounter the least resistance in implementation, and not with what is likely to be effective in achieving trip reduction goals. Most would regard this as only common sense, that implementors would be conservative on a controversial issue like changing travel behavior or underlying business practices, given political pressures and uncertainty as to the payoff potential (risk factor) of the alternative courses of actions. The general result, however, has been a majority of programs with conservative designs and little or no impact.

The general finding when considering the body of empirical evidence is that most (if not all) of the success stories in TDM are found at the level of the individual site, and not in the more sweeping, visible, area-wide programs. By area-wide, this implies everything from regional transit and ridesharing programs to Transportation Management Associations, to trip reduction ordinances in support of air quality, traffic congestion or growth management themes. The reasons for this seem to be quite clear. The large area-wide programs -- covering everything from a metropolitan region to a major business park -- typically do not prescribe or impose the types of measures that are basic to changing behavior. They may be motivated by legal requirements, but still do not cause the necessary measures to be incorporated.

On the other hand, it often happens that an individual employer within one of these zones may -- accidently or with some forethought -- apply just the right measures and cause genuine change in trip making (20 percent to almost 50 percent net reductions in vehicle trips). Usually they do this without having been directly compelled to implement the particular measure or measures, but did so because it seemed most efficient or effective to their situation, because they felt they could implement it, because they were facing some type of internal economic pressure, or -- again -- because they fell upon it purely by accident. Regardless of the path, we are left with a number of quality examples which indicate that TDM can have significant travel impact, and that provide insights as to which measures contribute to this success.

This does not imply that the area-wide program efforts have been without value or contribution -- because some significant innovations have come out of such efforts -- but rather that they have fallen far short of potential. The challenge, instead, is to see what caused the successful individual sites to have impact, and then determine how to utilize this information to improve the effectiveness of TDM at the area-wide level.

3.2.2. Measurement Methodology

In an earlier FHWA study, *"Evaluation of Travel Demand Management Measures to Relieve Congestion"* a methodology was developed to measure the trip reduction accomplishments of ongoing TDM programs. The report subsequently listed and described the trip reduction accomplishments of a number of TDM programs across the country.

The trip reduction was ensured through a two-part methodology:

1. VEHICLE TRIP GENERATION RATE

The first step was to measure and document the vehicle trip-making intensity of the particular example, or in other words, the ratio of vehicle trips to the movement of people in the travel population. This was described in terms of *vehicle trips per 100 travelers*. Similar to a measure of vehicle occupancy rate, this measure is more complete in that it consists of all people traveling to a site (or in a corridor, depending on context of example), including public transportation users and non-motorized vehicle travelers, related to the number of vehicle trips. This information is generally derived from travel surveys which establish modal split, and involves the calculation of vehicle trips based on the following loading factors:

- **Drive Alone/Motorcycle:** 1 person trip = 1 vehicle trip
- **Carpool:** 1 person trip = 0.4 vehicle trip (2.5 persons per vehicle)
- **Vanpool:** 1 person trip = 0.083 vehicle trip (12 persons per vehicle)
- **Transit:** 1 person trip = 0.033 vehicle trip (30 persons per vehicle)
- **Bicycle/Walking:** 1 person trip = 0 vehicle trips

Generally speaking, the closer this index approaches 100 (vehicle trips per 100 population), the more vehicle dependent the population.

2. REFERENCE BASE

The vehicle trip rate resulting from a TDM program action is only a useful measure of performance if it can be qualified against the alternative of *no action*. Clearly, in the absence of a TDM program it is not reasonable to assume that all travelers would have traveled in a single-occupant vehicle (SOV) in the peak hour. Even in the most automobile-dominated environments, some travelers will employ other methods of travel, due to background/marketplace or personal/sociodemographic factors. The true measure of the TDM program's impact is to gauge the travel distribution with the program in place vs. some "background" standard. Three measures were employed, depending on the situation and availability of data:

(1) The example itself before the TDM program;

(2) A highly similar situation elsewhere where there is no TDM;

(3) The surrounding subarea or region where TDM is not being applied or where its effects are negligible.

An example of how this methodology is used to calculate *net vehicle trip reduction* is provided in Table 3.2-1. In this example, we have a hypothetical employment site with 1,000 travelers where the employer has applied TDM measures. Using the vehicle loading rates outlined in the methodology above, the modal split of the example program results in a vehicle trip rate of 71.0 vehicle trips per every 100 travelers; for a company with 1,000 employees, this translates to 710 daily one-way vehicle trips. To ascertain how effective this set of program actions is, the example is compared against a very similar employment site in the same general area, but where TDM measures are not being applied. Reviewing modal split data for this control site results in a vehicle trip rate of 86.4 vehicle trips per 100 travelers. Thus, if the TDM site had done nothing, it is reasonable to assume that its employees would have been travelling at the rate of the control site, and generating 864 vehicle trips instead of 710. This difference amounts to a 17.8 percent *net reduction* in vehicle trip making, and eliminates 178 daily vehicle trips.

3.2.3. Review of Case Studies

Table 3.2-2 lists 22 employer-based TDM programs whose performance has been reviewed through case studies. The table presents for each of the sites: size of travel base (employment); vehicle trip rate resulting from TDM program; comparative trip rate from control site and type of control site; and calculated net vehicle trip reduction.

TABLE 3.2-1

Sample Trip Reduction Calculation

Modal Split	TDM Site (1,000 Travelers)	Comparison Site
Drive Alone	63%	82%
Carpool	19%	11%
Vanpool	1%	1%
Transit	11%	3%
Walk/Bike/Other	6%	3%
Vehicle Trip Rate	71.0 per 100	86.4 per 100
Percent Reduction:	(86.4 - 71.0) / 86.4 = **17.8%**	
Vehicle Trips Removed:	17.8% x 1,000 = **178 daily one-way trips**	

The sites are listed in declining order of trip reduction performance. As can be seen, the trip reduction performance of the cases constitutes quite a range, from a high of 47.9 percent for Travelers Insurance to a low of 3.7 percent at Chevron. In the section below, a quick summary of the program at each site is presented which reveals the major elements of the program. Following this is an analysis of those characteristics that appear to explain the difference in performance among the sites, and provide the basis for identifying important TDM program components.

1) Travelers Insurance

Travelers Insurance is the largest insurance company in Hartford, Connecticut with an employment base of 10,000 employees. Due to its downtown location with scarce and expensive parking, the company instituted a broad program of measures to encourage use of alternative modes. These measures include:

- *Restricted Parking:* The company provides only 4,700 spaces for its 10,000 employees, with only 1,500 of these on-site.

- *Parking Charges:* Travelers Insurance pays $30 to $70 per month per space and in turn charges employees a portion of those costs. Drive-alones are charged $25/month, two-person carpools $15/month, and three-or-more person pools park free.

TABLE 3.2-2
Summary of TDM Program Results
Individual Sites

Employer Location	*Travel Base(1)*	*Vehicle Trip Rate(2)*	*Comparison Basis(3)*	*Comparison Trip Rate(2)*	*Net Vehicle Trip Reduction*
Travelers Insurance, Hartford, CT	10,000	42.8	2	82.1	47.9%
US West Bellevue, WA	1,150	45.2	3	83.1	47.1%
Nuclear Regulatory Commission, Montgomery County, MD	1,400	53.7	3	91.9	41.6%
GEICO Montgomery County, MD	2,500	40.8	3	74.2	38.6%
CH2M Hill Bellevue, WA	400	59.4	3	86.4	31.2%
State Farm Orange County, CA	980	64.3	3	92.4	30.4%
Pacific Bell San Ramon, CA	6,900	72.8	2	93.0	27.8%
Hartford Steam Boiler Hartford, CT	1,100	49.6	2	67.5	26.5%
Swedish Hospital Seattle, WA	2,500	43.6	1	59.0	26.1%
Bellevue City Hall Bellevue, WA	600	64.1	2	86.4	25.8%
San Diego Trust & Savings, San Diego, CA	500	51.0	3	66.0	22.7%

Comparison Basis:
1 = Same site Before TDM
2 = Comparitive site w/o TDM
3 = Surrounding subarea/region

TABLE 3.2-2 cont.
Summary of TDM Program Results
Individual Sites

Employer Location	*Travel Base(1)*	*Vehicle Trip Rate(2)*	*Comparison Basis(3)*	*Comparison Trip Rate(2)*	*Net Vehicle Trip Reduction*
Pasadena City Hall, Pasadena, CA	350	68.9	1	87.4	21.0%
Trans/America, Los Angeles, CA	2,700	55.5	3	69.3	20.0%
ARCO, Los Angeles, CA	2,000	55.3	3	83.6	19.1%
Varian Palo Alto, CA	3,200	70.9	1	86.2	17.7%
AT & T Pleasanton, CA	3,890	80.5	2	93.0	13.4%
Ventura Co Ventura County, CA	1,850	78.0	1	90.0	13.0%
COMSIS Silver Spring, MD	130	66.4	3	74.2	10.5%
3M Company St. Paul, MN	12,700	82.7	1	91.6	9.7%
Allergan Irvine, CA	1,250	83.0	1	89.1	7.0%
UCLA (Employees) Westwood, CA	18,000	79.0	3	83.6	5.5%
Chevron Concord, CA	2,300	78.0	1	90.4	3.7%

Comparison Basis:
1 = Same site Before TDM
2 = Comparitive site w/o TDM
3 = Surrounding subarea/region

- *Transit Subsidies:* A $15/month bus pass subsidy is offered.

- *Vanpool Program:* The company operates a vanpool program which costs them a net $20 per user per month.

As a result of these measures, the mode split for Travelers' employees is 33.2 percent drive-alone, 19.4 percent carpool, 8 percent vanpool and 36.2 percent transit. Travelers is located conveniently near a downtown terminus of regional bus operations, so it enjoys access to good transit service and it endeavors to take maximum advantage of that situation. This mode split corresponds to a vehicle trip rate of 42.8 trips per 100. The comparison trip rate of 82.1 per 100 represents another large insurance company in the downtown.

2) <u>US WEST Communications</u>

US WEST is a communications firm located in Bellevue, Washington, a new suburban downtown located just east of Seattle. While downtown Bellevue does not have a TDM ordinance, new buildings are subject to restrictions in terms of parking ratios (2.4 per 1,000 square feet), reduced building setback formulas, and requirements to implement a transportation management program. When it consolidated its regional operations into its new, company-owned building in Bellevue, US WEST conformed to these requirements with the following program:

- Restricted on-site parking by constructing a garage with only 408 spaces for 1,150 employees.

- Charge for parking: $60 per month for drive-alone, $45 for two-person carpools, and no charge for pools of three or more.

- Reserved parking for HOV's, with SOV spaces available only on a first-come, first-served basis.

- Flexible work hours.

- On-site transportation coordinator.

With this set of conditions facing employees, the company has documented a mode split of 26 percent drive-alone, 47 percent rideshare, 13 percent transit, 13 percent multimodal and 2 percent other, for a vehicle trip rate of 40.8 per 100. To assess its net trip reduction, US WEST was compared to the remainder of employers in downtown Bellevue (less US WEST). A vehicle trip rate for the control of 83.1 compared to US WEST's 40.8 translates to a trip reduction of 47.1 percent.

3) <u>Nuclear Regulatory Commission</u>

The Nuclear Regulatory Commission (NRC) is located in North Bethesda, a medium-density suburb of Montgomery County, Maryland (suburban Washington, D.C.). While North Bethesda is heavily oriented to SOV travel (strip development and various business enclaves), the NRC site is located within walking distance of a MetroRail station. There is also reasonable public bus service through the area, although it functions largely as feeder support to Metro.

NRC's TDM program was brought about because of the County's Adequate Public Facilities Ordinance, which denied NRC approval to develop the second of two buildings planned for the site at White Flint North. NRC needed the second building in order to complete its relocation of 2,450 staff. Through a comprehensive set of TDM actions, NRC was able to reduce vehicle traffic sufficiently at its first building that it was given approval to proceed with the second.

The TDM measures in the NRC's program included:

- Restricted on-site parking by providing only 365 spaces on-site for 1,400 employees.
- Fee parking $60 per month charge for all users, with no discount allowed for HOV's.
- Guaranteed parking for carpools.
- Nearby parking restrictions, with instructions to tow from adjacent lots.
- Transit subsidies provided by the County, since NRC as a federal government agency is not allowed to subsidize employee travel.

Through a combination of measures, NRC was able to cause a modal split of its 1400 employees at One White Flint North of 42 percent drive-alone, 27 percent carpool, 28 percent transit and 3 percent other, corresponding to a vehicle trip rate of 53.7 vehicle trips per 100 employees. Employees in North Bethesda as a whole were surveyed in 1987 as part of the "North Bethesda Traffic Mitigation Study", and were found to have a mode split of 89.5 percent drive-alone, 6.5 percent carpool, 4 percent transit, and 0 percent other, for a trip rate of 91.9 per 100 employees. Using this as the background measure, a net trip reduction for NRC is estimated at 41.6 percent.

4) GEICO Insurance

Another company subjected to in Montgomery County, Maryland's Adequate Public Facilities Ordinance is GEICO Insurance. GEICO had to develop a program of TDM actions which the county would find acceptable in achieving a vehicle trip generation target. In order to consolidate 2,500 staff into its planned new headquarters in Friendship Heights a medium-density, inner-city suburb of Washington, D.C. with many characteristics of a suburban downtown including some scarcity of parking. Like NRC, the GEICO building was also fortunate to be within walking distance of a MetroRail station.

Elements of GEICO's TDM plan include:

- *Restricted parking* Only 1,020 spaces on site for 2,500 employees.
- *Charge for parking* $30 to $60 per month in garage, $10 per month in lot.
- *Free parking* for carpools and vanpools.
- *Reserved spaces* for carpools and vanpools.
- *Subsidized vanpool program* (28 pools).
- *Transit subsidies* with 50/50 county match.

The company's program of TDM actions has produced a modal split of 40 percent drive-alone, 20 percent rideshare, 31 percent transit and 8 percent other. This equates with a vehicle trip rate of 40.8 per 100. Since no comparison measure could be found for the Friendship Heights vicinity, the measure of 74.2 trips per 100 for nearby Silver Spring was used, assuming the levels of transit service and use were similar, and parking conditions were similarly constrained. This comparison implies a net trip reduction of 38.6 percent.

5) CH_2M Hill

CH_2M Hill is a consulting firm located in the Bellevue, Washington central business district (CBD). When the company moved to Bellevue from a more suburban location (where it had ample free parking), it realized that it would not have enough parking at the site for all of its present staff, but even worse, the parking lease would entitle them to less parking over time (number of spaces was programmed to diminish over time), whereas the company was planning for significant growth. This parking condition was a result of the development controls administered by the City of Bellevue as described in the US WEST discussion.

The TDM program conceived by CH_2M Hill employed the following strategies:

- *Transportation Allowance:* All existing employees were given a one-time increase in salary amounting to $40 per month to serve as a means to compensate for the cost of parking in at the new site.

- *Parking Charges:* Employees were charged for parking at the new site in the amount of $40 per vehicle, which represented an <u>overpayment</u> of the actual lease cost per space. The overpayment was used to fund incentives.

- *Free Parking for Carpools:* Carpool units of two or more were offered free parking in the garage.

- *Transit Subsidy:* Transit users were given a subsidy of $15 per month over and above the transportation allowance.

As a result of these TDM strategies, mode split for the 400 employees at the new site was 54 percent drive-alone, 12 percent carpool, 17 percent transit and 17 percent other, corresponding to a vehicle trip rate of 59.4 per 100. To determine the net reduction represented by this mode split, CH_2M Hill was compared to a system of regional control sites developed by Seattle Metro, corresponding to a vehicle trip rate of 86.4 trips per 100; this translates to a trip reduction of 31.2 percent.

6) <u>State Farm Insurance</u>

State Farm Insurance's Southern California Regional Office is located in Costa Mesa, which is south of Los Angeles in Orange County, California. The building is located in a large suburban office park which is highly oriented to private vehicle travel. The State Farm building is a one-story structure surrounded by ample, free surface parking for all its employees. There is little or no transit service to the site.

Prior to falling under the mandatory trip reduction requirements of Regulation XV, State Farm had a moderate employee transportation program in place. They operated one vanpool and encouraged employee ridesharing with marketing and informational ploys. Under Regulation XV, however, they had to devise improvements to their efforts sufficient to raise the Average Vehicle Ridership (total 6:00 a.m. to 10:00 a.m. person trips divided by total vehicle trips) for their 1,000 employees to a 1.50 standard.

In addition to increasing their support of ridesharing, the company devised a transportation subsidy program. Each day, as employees arrive at the company's on-site parking lot, an attendant checks the occupancy of the vehicle and issues coupons worth a particular subsidy amount. The coupons are accumulated by the employee and returned for cash redemption at the close of a pay period. The value of the subsidy is as follows:

- Each person in a two-person pool receives a $.50 coupon;
- Each person in a three-person pool receives a $1 coupon;
- Each person in a pool of four or more, or who reaches work by walking or bicycle, receives a coupon worth $1.50.

Employees accumulate the coupons they earn and later redeem them for payment at the end of the period. The result of this program was to shift an additional 120 of the company's 1000 employees into carpools, and increase the average occupancy level from 1.22 to 1.55 within two months. The modal split after the program change increased from 78 percent drive-alone, 20 percent carpool, 1 percent vanpool and 1 percent other to 66 percent drive-alone, 31 percent carpool, 2 percent vanpool and 1 percent other. This corresponds to a vehicle trip rate of 64.3 per 100 employees, and when compared with the surrounding area, amounts to a trip reduction of 30.4 percent.

7) <u>Pacific Bell</u>

This installation of Pacific Bell is a regional administrative and service headquarters with about 6,900 employees, located in the Bishop Ranch, California business park, about 35 miles east of San Francisco. This remote exurban location requires great dependence on private vehicle travel. Most employees at the business park have experienced major relocation from work locations and residences close to the San Francisco core. Transit service is very minimal, consisting of a 10+ -mile feeder bus connection to the BART stations at Walnut Creek and Lafayette to the north.

Pacific Bell's involvement in TDM stemmed from two motives: (1) an Alameda County trip reduction ordinance that required employers to institute measures that would produce a peak hour vehicle trip rate that would amount to a 40 percent reduction over the condition where all employees would drive alone during the morning peak hour; and (2) to provide assistance to employees who were experiencing major new difficulty in commuting to work over such a long distance.

To address these special needs, Pacific Bell developed a TDM program with the following elements:

- *Restricted Parking:* Provision of only 4,600 surface spaces on site for 6,900 employees, with reserved close-in parking for pools.

- A full-time, on-site *transportation coordinator.*

- *Rideshare matching* program.

- *Vanpool* program.

- Contract *shuttle service* to BART stations at Walnut Creek and Lafayette.

- *Flexible work hours.*

No financial incentive measures are used. As a result of its efforts, Pacific Bell achieved a mode split of 63 percent drive-alone, 22 percent carpool, 11 percent vanpool, 2 percent transit and 2 percent other. This translates to a vehicle trip rate of 72.8 per 100, which corresponds to a net trip reduction of 27.8 percent when compared to a set of nearby regional control sites.

8) <u>Hartford Steam Boiler</u>

Hartford Steam Boiler (HSB) is another insurance firm located in downtown Hartford, Connecticut with 1,100 employees. Under motivations similar to those of Travelers Insurance -- scarce and expensive parking for employees -- HSB has developed a comprehensive TDM program that has the following elements:

- *Restricted Parking:* The company makes available only 233 spaces for its employees.

- *Charge for Parking:* The spaces cost HSB $110 per month. HSB in turn charges SOV users full cost $110, two person carpools $75, three person pools $40, and pools of four or more $10.

- *Subsidies*: To transit and vanpool users ranging from $10 to $30 per month.

As a result of this program, HSB can point to a mode split of 39.9 percent drive-alone, 20.9 percent carpool, 1.3 percent vanpool, and 35.9 percent transit, equal to a vehicle trip rate of 49.6 per 100. Compared to a similar firm located nearby without an active TDM program with a trip rate of 67.5 per 100, HSB is credited with a net trip reduction of 26.5 percent.

9) <u>Swedish Hospital</u>

Swedish Hospital Medical Center is a large hospital and medical office complex located on a 10-block site in the First Hill section of Seattle, an inner suburb located east of the downtown. The site's employment is more than 3,400, of which approximately two-thirds work the day shift. The Center began its TDM program in 1985, under an agreement with the City of Seattle; in order to receive approval on its 20-year development plan, the hospital was required to reduce daytime SOV trips to no more than 50 percent of the total trips by employees to the site.

The initial program started in 1985 included three primary elements:

- *Parking Charges:* A monthly fee of $22 for SOVs.
- *Carpool Parking Subsidy*: A monthly parking fee for carpools of $5, plus $1 per passenger.
- *Transit Subsidy*: A subsidy of $15 per month.

By 1987, the hospital realized that these measures were not sufficient to produce the required trip reduction, and invoked the following additional measures:

- *Parking Surcharges*: A schedule of increases in the monthly fee to $44/month for SOVs by 1990, while freezing carpool rates at 1985 levels.
- *Restricted Parking:* No new day-shift SOV parking.
- *Transit Subsidy*: Increased to 100 percent of fare.
- *Transit Service*: A special contract arrangement with Seattle Metro to provide express services directly to the hospital complex.
- *Guaranteed Ride Home:* For First Hill Express riders.
- *Vanpool Subsidy*: Up to six months' operating cost subsidy.
- *Flexible Work Hours:* In select departments and jobs.

As a result of this program of actions, Swedish's 1990 modal split was 33 percent drive alone, 23 percent carpool, and 44 percent transit (no vanpools reported operating), resulting in a vehicle trip rate of 43.6 trips per 100. Comparing this to the Complex's 1987 rate of 59.0 as a control (pre-1987 statistics unavailable) results in a net trip reduction of 26.1 percent, which is a very conservative estimate of their overall performance since it registers only the incremental improvement over a reasonable program already in place.

10) Bellevue City Hall

The City of Bellevue, Washington (suburban Seattle) determined that, since it was attempting to lead an ethic of "sensible" travel and traffic management in the Bellevue area, it should also maintain an exemplary program of its own and also reduce demand for parking and improve access to the government facilities. The City Hall/Leavitt complex of buildings receiving the program, where approximately 600 people are employed, is located in a separate business complex, outside the Bellevue downtown. Dependency of employees on private vehicle to reach the site and for access to services once at the site is apparent.

The elements of the City's TDM program included:

- *Parking Charges:* All full-time employees (those working 22.5 hours or more per week) charged $30 per month to park SOVs at the site; part-time employees are charged $15. Fees are deducted from the paycheck.

- *Parking Charge Exemptions:* Any employee using an alternative mode is exempt from the parking deduction from the paycheck.

- *Priority Parking*: Those who carpool/vanpool at least 60 percent of the time (monthly basis) receive priority parking.

- *Alternate Mode Subsidies:* Those who use alternate modes at least 80 percent of the time receive the following subsidies:

  Carpoolers: $15 per month

  Vanpoolers: $25 per month

  Transit Users: Subsidy equivalent to one-zone peak fare cost.

  Bike/Walk/Motorcycle: $15 per month.

The system of fees and subsidies is managed to be self-sustaining, i.e., to operate with zero net cost to the City.

The program has resulted in a modal split of 52 percent SOV, 6.8 percent transit, 28.9 percent carpool/fleetride, 3.7 percent vanpool, and 8.5 percent other. This results in a vehicle trip generation rate of 64.1 per 100, which corresponds to a net trip reduction of 25.8 percent when compared to Metro's regional control sites (rate of 86.4).

11) San Diego Trust and Savings

San Diego Trust and Savings (SDTS) is a large, full-service bank located in downtown San Diego with about 500 employees. Because of the downtown location, its employees realize constraints on parking, but at the same time, easy access to good transit service. The company instituted a program of commute benefits for its employees back in 1972, to compensate downtown employees for the lack of free parking enjoyed by the suburban employees; the bank provided a parking subsidy to SOV commuters, with carpoolers receiving a higher subsidy, and a 100 percent subsidy to transit users.

In 1991, stimulated by a trip reduction ordinance imposed by the City of San Diego, the bank altered its package of benefits to include the following:

- *Parking Subsidy*: $55/month for SOVs, $70/month for two-person pools, and $100/month for three-person pools.
- *Transit Subsidy*: 125 percent of fare (average of $60/month).
- *Ridematching*: Support of rideshare matching through the regional agency.
- *Flexible Work Hours*: Through arrangement with individual departments.

In addition to the above tangible incentive measures, the company also maintained a policy of active corporate support behind the use of alternatives, including flexibility in arrival and departure times and a policy of not holding meetings late in the day. As a result of these measures, the bank has achieved a modal split of 44 percent SOV, 14 percent carpool, 37 percent transit and 5 percent other, contributing to a vehicle trip rate of 51 per 100. Compared to an average of other employers downtown (66 per 100), the trip rate of SDTS amounts to a net trip reduction of 23 percent. Compared to six other major banks downtown, SDTS achieves a 28 percent reduction.

12) Pasadena City Hall

The City of Pasadena started its TDM program in 1989 in response to a local air-quality based trip reduction ordinance. A supporting reason for the program was to give benefits to employees using alternative modes and to serve as an example to other area employers. Employees numbering 1,700 of the City's 2,100 are covered by the program, 500 of whom work at the City Hall site in downtown Pasadena.

The City's program includes parking fees as well as incentives to employees to use alternative modes. There is no on-site parking; however, employees may find adequate parking in nearby facilities that were paid for by the City. Eight transit routes service the site. Specific elements include:

- *Parking Charges:* $45/month for SOVs, $10/month for two-person pools, and free for pools of three or more.
- *Transportation Allowance:* $20/month for all employees.
- *Carpool Subsidies:* $10/month gasoline subsidy; use of city vehicles for pools of three or more; $40/month childcare subsidy.
- *Vanpool Subsidies:* $30/month gasoline subsidy; six month start up incentive ($240 per rider); empty seat subsidy (up to five seats) for three months.
- *Transit Subsidies:* "free" transit (up to $42/month) pass; free shuttle taxi service for employees within five miles.
- *Bike/Walk Subsidies:* $40/quarterly payments to bike/walk; rebates on bike and helmet purchases; shower/locker availability.
- *Supporting Measures:* SOV occasional parking for HOV users; guaranteed ride home; on-site ridematching; work hours flexibility and compressed work weeks; both a full-time and a part-time on-site transportation coordinator.

This system of measures has resulted in an employee modal split of 58 percent SOV, 27 percent carpool, 7 percent transit and 2 percent vanpool, plus 6 percent other, corresponding to a vehicle trip rate of 68.9. Compared to City Hall in 1989 before the program (rate of 87.4), this amounts to a net trip reduction of 21 percent.

13) Transamerica Life

Transamerica Life Companies is an insurance company with more than 3,000 employees located in Transamerica Center, a multi-building office complex 10 blocks south of the Los Angeles CBD. Characteristics of the site resemble the accessibility and travel characteristics of the downtown: services and bus service within walking distance and constrained parking.

Transamerica Life's TDM program has developed in stages under different motivations. The first stage of the program, begun in 1979, was effectively a vanpool program started at the request of employees. Elements of Transamerica's initial program include:

- *Vanpool Formation:* Bought and leased back vans, arranged for maintenance and insurance, recruited riders and administered program.

- *Vanpool Parking:* Constructed and maintained a free vanpool parking lot adjacent to the building.

- *Carpool Parking:* In the mid-1980's, carpools of three or more were provided with preferential parking (and taken off the wait list).

This program was very successful, with 860 Transamerica employees commuting by vanpool in 1987. In 1988, the company expanded its program to comply with a City trip reduction ordinance to address its parking shortage. To comply with this ordinance, the company implemented the following measures:

- *Parking Charges*: Increased from $10/month to $35 to $62/month (though the market rate for parking was $100); Carpools given a discount of $10/pool plus $15 subsidy for each additional passenger.

- *Transit Subsidy*: A subsidy of $15/month was started.

Later in 1990, under impetus of Regulation XV, the company instituted some additional support measures: guaranteed ride home; emergency use of company cars; work hours flexibility; and bike racks and shower/locker facilities.

As a result of these measures, the modal split of Transamerica in 1991 was 45 percent SOV, 21 percent carpool, 14 percent transit, 19 percent vanpool, and 1 percent other. This corresponds to a vehicle trip rate of 55.5, which compared with an average for the Los Angeles CBD of 69.3, amounts to a net trip reduction of 19.9 percent.

14) Atlantic Richfield Company (ARCO)

ARCO is located in downtown Los Angeles' Century Plaza, and had implemented an employee commute management program considerably in advance of the formal requirement to do so under Regulation XV. Its motivations were both economic (cost of parking) and corporate ethic in being a leader in employer transportation programs.

The components of the ARCO program included:

- *Restricted Parking:* The company leases 650 spaces for its 1,500 employees; these are located in garage facilities where parking is relatively scarce and expensive.

- *Charge for Parking:* The company pays $130/month for its leased spaces, and pays 1/3 of the cost for drive-alones, 2/3 of the cost for two-person pools, and gives them free to pools of three or more persons.

- *Transportation Allowance:* ARCO gives a $15 monthly subsidy allowance to employees who rideshare and use transit.

- *Vanpool Program:* ARCO leases vans and charges users an average of $60/month for their use; because it can absorb a variety of the costs, this is judged to be an additional $10/month subsidy to users.

- *Guaranteed Ride Home Program:* Use of rental car for emergencies at substantially reduced rates.

The result of these various measures has given ARCO a mode split of 46 percent drive-alone, 20 percent carpool, 14 percent vanpool, and 20 percent transit. This corresponds to a vehicle trip rate of 55.3 per 100. When compared to the average for the Los Angeles CBD of 68.3, this amounts to a net trip reduction of 19.1 percent.

15) <u>Varian Company</u>

The Varian Company employs about 4,500 people in several locations throughout the San Francisco Bay Area. About 3,200 employees are housed at a 19-building suburban office complex at the main site in Palo Alto. Parking at the site is free, tight and well-utilized, with no on-street parking. Bus transit is reasonably available in the area.

Varian's TDM program began in 1980 before any TDM regulations were in place, to address parking and access problems. However, in 1990/91, TSM ordinances were adopted by Santa Clara and San Mateo counties, where Varian is located, that placed additional emphasis on their efforts.

Varian's early TDM efforts (1980 - 83) were modest, including an in-house carpool matching system, on-site transit pass sales (no discount), and promotion of carpooling, cycling and transit. Between 1984 and 1991 the program became much more aggressive, with incorporation of the following additional elements:

- *HOV Incentives:* 25 percent transit pass discount; award program for transit and rideshare patrons.

- *Increased Employer Support:* On-site TDM coordinator; bike and shower facilities; new employee orientation materials and annual commute fair.

The mode split for Varian in accord with this program of measures was 62 percent SOV, 21 percent carpool, 3 percent vanpool, 8 percent transit, and 6 percent other, corresponding to a vehicle trip rate of 70.9 trips per 100. Compared to the company's performance in 1980-83, when the trip rate was 86.2 per 100, this represents a net trip reduction of 17.7 percent.

16) AT&T

AT&T's Hacienda Business Park, located in Pleasanton, California, is a large operation which employs 3,900 people. The entire business park was put under a model TDM trip reduction ordinance by the City of Pleasanton, which required actions taken by employers to accomplish a 40 percent reduction in vehicle trip generation compared to the basis that all employees would drive alone in the peak hour.

As principal components of its trip reduction plan, AT&T offered the following set of actions:

- *Restricted Parking*: Construction of only 2,950 spaces for an estimated employee population of 3,890.
- *Preferential Parking*: Close in, reserved parking for carpools and vanpools.
- Active *rideshare matching* and promotion program.
- *Flexible work hours.*

AT&T does not price its parking, and can attribute most of the success of its program to a relocation assistance program. When the company consolidated operations from the city of San Francisco to this remote exurban location, many employees were faced with extremely long commutes, and it became fairly easy for AT&T to help them form pools. Over time, however, many of these employees have either found new jobs or moved closer to the site, with the result that drive-alone rates have climbed steadily.

In 1990, AT&T's mode split was 71 percent drive-alone, 22 percent carpool, 3.2 percent vanpool, 2.4 percent transit, and 1 percent other. This equates with a vehicle trip rate of 80.5 per 100. To ascertain net trip reduction, this rate was compared to a sample of regional control sites consisting of two similar areas with no or minimal TDM efforts (Santa Rosa and Walnut Creek); this group has a trip rate of 93.0 per 100, resulting in a net trip reduction credit for AT&T of 486 trips, or 13.4 percent.

17) Ventura County

The County of Ventura employs about 6,700 people in numerous office sites throughout the county, located west of Los Angeles. The headquarters and largest site is the Government Center, which employs about 2,700 administrative and judicial personnel in a suburban setting about five miles from downtown Ventura. Neither the county nor the site is well-served by transit, and the site has abundant, free on-site parking.

The county's TDM program was initiated in 1990, in response to a county air quality regulation. From responses to an employee survey, county staff learned that cash was a more desirable incentive to induce use of alternative modes than any other incentive. But, rather than offer monthly subsidies or incentives for specific modes, the county implemented a yearly incentive that rewards employees based on the number of days they don't drive alone during the year, regardless of the alternative used. Specifically:

- *Point Accumulation:* Employees receive one "point" for every day of the year they do not drive alone to work.

- *Compensation:* Employees who accumulate 144 points (average of 3 times per week) receive a $300 cash payment; employees who accumulate 96 points (average of 2 times a week) receive a $200 cash payment.

- *Support Measures*: Guaranteed ride home program, preferential parking, and bike/walk facilities.

The County's vehicle trip rate decreased from 90 per 100 to 78 per 100 during the five-month period following introduction of this program, reflecting a mode split of 69 percent SOV, 23 percent carpool, 2 percent transit and 6 percent other. This represents a 13 percent net vehicle trip reduction.

18) COMSIS Corporation

COMSIS Corporation is a consulting firm which relocated its operations in 1988 from offices in Wheaton, Maryland, an outlying suburb of Montgomery County to Silver Spring, a suburban CBD. Montgomery County's imposition of trip reduction requirements for Silver Spring meant that COMSIS had to develop a trip reduction plan prior to the move in support of the Silver Spring Transportation Management District.

The elements of the COMSIS TDM plan included:

- *Restricted Parking:* Restriction in free on-site parking to only 30 spaces for 130 employees.

- Provision of a *transportation allowance* in the amount of $60/month to all pre-move employees, furnished through a one-time increase in salary. The allowance was designed to equal the market cost of parking (before taxes).

- Carpool and transit monthly *subsidies* (with county match).

Prior to the company relocation, virtually 100 percent of all employees drove alone to work, given unlimited free on-site parking. Following the move, the modal split was 54 percent drive-alone, 25 percent carpool, 18 percent transit, and 3 percent other, corresponding to a vehicle trip rate of 66.4 per 100. If the pre-move condition is used as the reference for what would have happened in the absence of a TDM program, then the program can be credited with a net trip reduction of 44 trips, or a 33.8 percent net trip reduction. However, if the mode split after relocation is compared to the average of Silver Spring employers, or 74.2 trips per 100, COMSIS has only reduced 10 vehicle trips and is credited with a net reduction of only 10.5 percent. Neither standard is without debate. The sample, which produced the average for downtown Silver Spring, was developed from a list of firms with active commuter assistance programs (supplied by the Montgomery County Rideshare office), so the background measure is substantially lower than average due to aggressive TDM programs. At the same time, using the pre-relocation mode split for COMSIS has some validity in that the company could have elected to adopt free parking as a policy for its employees in the absence of the Transportation District requirement.

19) <u>3M Company</u>

3M is a major technology/light manufacturing firm located in a remote, private business park east of St. Paul, Minnesota. About 12,700 people are employed at the company's 3M Center complex. 3M's pursuit of a commute management (TDM) program has been ongoing since 1970, and motivated entirely by internal objectives. These objectives have included: making access to the site convenient for employees; alleviating traffic congestion problems at/nearby the site following periods of employment growth; solving commute problems during energy shortage periods in the 70's; and finding adequate space for new buildings at the site during periods of expansion.

The company has devised and implemented the following program measures over time:

- *Staggered Work Hours:* Split the work force into two groups, administrative and scientist, with arrival times staggered 1/2 hour apart.

- *Subscription Bus Program*: Contracted with the regional transit provider for service to select concentrations of employees.

- *Carpool Program*: Provided a centralized matching system for interested employees.

- *Vanpool Program*: The most intensive program, provided assistance in formulation of pools, acquisition of vehicles at attractive rates, free insurance, and empty seat subsidies.

Without doubt, the staggered hours and the vanpool program have been the staples of the 3M program. The staggered hours, which split the work staff arrival into two groups, immediately solved a major congestion problem that had developed in the early 70's. The Vanpool program has been a nameplate for 3M, and one in which they have taken great corporate pride and ownership. The pools are a large part of the culture of the firm. 3M does not in any way manage its parking supply to encourage ridesharing, nor does it make use of any incentives or disincentives, other than those that are implicitly offered through the vanpool program.

In 1985, the 3M program had a modal split of 82.7 percent SOV, 14.1 percent carpool, 7.8 percent vanpool and 1.7 percent transit, amounting to a vehicle trip rate of 82.7 per 100. This figure may be compared to pre-program conditions in 1970, when the trip rate was 91.6, leading to a credited vehicle trip reduction of 9.7 percent. However, it must be noted that the 1985 statistics were considerably worse than in 1980 when the program peaked (79.9 trip rate), and preliminary data for 1990 indicated an even higher regression to SOV use.

20) <u>Allergan</u>

Allergan is a manufacturer of health care products located in Irvine, California. The company employs about 1,750 people in two office sites, with 1,290 of these employed at the headquarters site located in a 28-acre campus development in the Irvine Business Park. The site is not within walking distance of off-site retail activity, but has many personal services on-site. The site has only limited transit service, and offers abundant free, on-site parking.

In 1979, Allergan implemented a subsidized vanpool program, where the company assumed the responsibility for most of the formation and administrative functions in operating the program, including van acquisition, arranging for maintenance and insurance, and assisting in rider recruitment. As incentives, they offer a company credit card for gasoline purchases, offer drivers free personal use of the vans, and provide a free trial week to interested employees. Employees who use the vanpools pay a straight $.05/mile fee through payroll deduction.

In 1988, the company expanded its program to comply with Regulation XV, consisting mainly of increased incentives:

- *Transit Subsidy:* 100 percent of cost.

- *Preferential Parking:* For all ridesharers.

- *Rideshare Incentive:* One extra paid holiday for persons ridesharing 30 percent of the time, two extra holidays if they rideshare 70 percent of time.

- *Support Measures*: Guaranteed ride home; walk/bike lockup/shower/change facilities; part-time transportation coordinator; information and promotional events and media.

- *Flexible Work Hours*: Set core of 9:00 a.m. to 3:00 p.m., with employee discretion to set actual arrival/departure hours.

As a result of this combination of TDM measures, Allergan's modal split is 76 percent SOV, 14 percent carpool, 7 percent vanpool, 1 percent transit and 2 percent other. This amounts to a vehicle trip rate of 83 per 100. Compared to the Orange County average of 89.9, this credits Allergan with a net vehicle trip reduction of 8 percent. Interestingly, Allergan's own vehicle trip rate in 1988 -- 89.1 per 100 -- was almost at the county average; the new incentive measures apparently produced much of the credited trip reduction.

21) UCLA

UCLA is located in the Westwood section of Los Angeles, a medium-to-high density suburban activity center which combines high-rise office employment with extensive retail and entertainment activity in a substantial residential community. UCLA employs about 18,000 people, exclusive of its student population. Because of its size, the community and the City have kept fairly continuous pressure on the university to be responsible for its transportation impacts.

A fairly elaborate transportation program has resulted that combines extensive parking facilities with active transportation service and management programs. Elements of this program have been in place since the early 1970's, and are now being spurred to higher levels of effectiveness by Regulation XV Air Quality directives.

UCLA's transportation program includes the following elements:

- *Restricted Parking:* Only 19,600 parking spaces on campus for a combined employee/student population of 50,000. There is a long wait list, although mainly for students.

- *Charge for Parking:* A monthly/daily rate of $30/$4 is charged to all staff and students, although these rates are considerably below market rates of $80-$120/$6-$10 in Westwood. No special parking rates for HOVs.

- *Vanpool Program:* A very active program with 65 vans in service; no implicit subsidy to riders.

- *Carpool Program:* Service contract with regional rideshare agency to perform matching, plus special parking permits (discounts and wait list priority, but no preferential/reserved spaces).

- *Transit Services*: Operates several local bus routes, shuttle services and park-and-rides, and also promotes (does not subsidize) use of public bus services.

This extensive set of program measures has produced a modal split for UCLA employees of 74 percent drive-alone, 10 percent carpool, 5 percent vanpool, 6 percent transit and 4 percent other. This corresponds to a vehicle trip rate of 79 vehicle trips per 100 employees. Compared with the LA region, which has an average trip rate of 83.6 per 100, this would credit the UCLA program with a net reduction of 5.5 percent.

22) <u>Chevron</u>

Chevron is a petroleum company with offices across the country. Chevron's Concord, California facility, primarily an accounting and billing center with 2,300 employees, is located on the outskirts of Concord, approximately 25 miles east of San Francisco. Approximately half of the employment force at this site was relocated from San Francisco in 1983/84 during a locational restructuring. The site is a suburban business campus, roughly four miles from the nearest BART station in Concord. The site has abundant free, on-site parking.

Chevron established its commuter program in 1983 as a condition of City of Concord development guidelines. The only requirement, however, was that Chevron operate a shuttle service to the BART system, though the company also opted to start a vanpool program. The program was later expanded to include other commute incentives to comply with a 1985 City ordinance to reduce peak hour trips, though no specific trip reduction goal is imposed.

Elements of Chevron's program include the following:

- *Shuttle Service*: Combines resources with two other employers to operate a free shuttle service to BART on 20-minute headways during the peak hours.

- *Vanpool Program*: Buys vans for employees' use, arranges for maintenance, self-insures vehicles, assists in rider recruitment, and maintains back-up vehicles; employees pay monthly fee related to trip length, covering all costs except insurance and program administration.

- *Rideshare Matching:* On-site and through the regional matching services of RIDES.

- *Preferential Parking*: For all pools.

- *Support Measures*: Guaranteed ride home; lock-up/shower/change facilities for bike/walk employees; on-site transit pass sales (with slight discount).

- *Flexible Work Hours*: Many employees can choose alternate work hours.

As a result of these program measures, the Chevron modal split is 82.2 percent SOV, 11 percent carpool, 5.2 percent vanpool, 0.7 percent transit, and 1.6 percent other. This amounts to a vehicle trip rate of 87.1 per 100, and only a 3.7 percent net vehicle trip reduction when compared to the average for employers in the Concord/Walnut Creek area. Indeed, prior to the incentive measures, Chevron was considerably worse than the average, and the measures help it improve to a position only somewhat more favorable than its peers.

3.2.4. Synthesis of Empirical Findings

The employer case studies in the previous section offer considerable insight as to the potential of TDM as a trip reduction strategy, as well as beginning to identity the factors that help produce effective programs. To facilitate the review of the relationship between these factors and program outcome, this section performs a cross-sectional analysis of the data from the case studies and offers conclusions as to important relationships. Table 3.2-3 tabulates key site and program characteristics for the 22 employer examples. The section below then describes the relationships seen by the reviewers in this data.

Least Important Factors

1) Employer Size

Popular wisdom suggests that larger firms have an easier time implementing successful TDM programs because of greater resources and a larger base of employees from which to form ridematching and other alternatives. ***However, the case studies show no clear relationship between size and effect;*** some of the smallest sites, like CH2M Hill, have some of the best results, and some of the largest, like UCLA, have the poorest results.

Table 3.2-3
Characteristics of Employer TDM Programs

Program	Vehicle Trip Reduction	Travel Base	Type Area(1)	Employer Support Level			Employee Modal Split(2)			
				Transit	Carpool	Vanpool	SOV	Transit	Carpool	Vanpool
Travelers Insurance	48.0%	10000	CBD	High	High	High	33	36	19	8
US West	47.1%	1150	SBD	Low	High	None	26	13	60	N/A
NRC	41.6%	1400	ISI	Med	Med	None	42	28	27	N/A
GEICO	38.6%	2500	SBD	High	High	High	40	31	20	8
CH2M Hill	31.2%	400	SBD	High	High	None	54	17	12	N/A
State Farm	30.4%	980	SBP	None	High	Med	66	N/A	31	2
Pacific Bell	27.8%	6900	SBP	High	High	Med	63	2	22	11
Hartford Steam Boiler	26.5%	1100	CBD	High	High	High	40	36	21	1
Swedish Hospital	26.1%	2500	ISI	High	Med	Med	33	44	23	N/A
Bellevue City Hall	25.8%	600	ISI	Med	High	Med	52	7	29	4
San Diego Trust & Saving	22.7%	500	CBD	High	Med	None	44	37	14	N/A
Pasadena City Hall	21.0%	350	SBD	High	High	High	58	7	27	2
TransAmerica	20.0%	2700	CBD	Med	Med	High	45	14	21	19
ARCO	19.1%	2000	CBD	Med	High	High	46	20	20	14
Varian	17.7%	3200	SBP	Med	Low	Low	62	8	21	3
AT&T	13.4%	3890	SBP	Low	Med	Med	71	2	22	3
Ventura County	13.0%	1850	OSI	Med	Med	None	69	2	23	N/A
COMSIS	10.5%	250	SBD	Med	Med	None	54	18	25	N/A
3M	9.7%	12700	OSI	Low	Low	High	83	2	14	8
Allergan	7.0%	1250	SBP	Med	Med	High	76	1	14	7
UCLA	5.5%	18000	ISI	High	Low	High	74	6	10	5
Chevron	3.7%	2300	SBP	High	Med	High	82	1	11	5

1 Key : CBD = Central Business District
OSI = Outter Suburb Isolated
SBD = Suburban Bussiness District
SBP = Suburban Business Park
ISI = Inner Suburb, Isolated

2 May not sum to 100% because of walk, bike, other.

Table 3.2-3 cont.
Characteristics of Employer TDM Programs

Program	*Vehicle Trip Reduction*	*Preferential Reserved Parking*	*Restricted Parking*	*Parking Charges*	*Subsidies*			*Legal Requirement*
					Transit	*Carpool*	*Vanpool*	
Travelers Insurance	47.9%	Y	Y	Y	Y	Y	Y	N
US West	47.1%	Y	Y	Y	N	Y	Y	Y
NRC	41.6%	Y	Y	Y	Y	N	N	Y
GEICO	38.6%	Y	Y	Y	Y	Y	Y	Y
CH2M Hill	31.2%	N	Y	Y	Y	Y	Y	Y
State Farm	30.4%	N	N	N	N	Y	Y	Y
Pacific Bell	27.8%	Y	Y	N	N	N	N	Y
Hartford Steam Boiler	26.5%	N	Y	Y	Y	Y	Y	N
Swedish Hospital	26.1%	N	Y	Y	Y	Y	Y	Y
Bellevue City Hall	25.8%	Y	Y	Y	Y	Y	Y	N
San Diego Trust & Saving	22.7%	N	Y	Y	Y	Y	N	Y
Pasadena City Hall	21.0%	N	Y	Y	Y	Y	Y	Y
TransAmerica	20.0%	Y	Y	Y	Y	Y	Y	Y
ARCO	19.1%	N	Y	Y	Y	Y	Y	Y
Varian	17.7%	N	Y	N	Y	Y	Y	Y
AT&T	13.4%	Y	Y	N	N	N	N	Y
Ventura County	13.0%	N	N	N	Y	Y	Y	Y
COMSIS	10.5%	N	Y	Y	Y	Y	N	Y
3M	9.7%	N	N	N	N	N	Y	N
Allergan	7.0%	Y	N	N	Y	N	Y	Y
UCLA	5.5%	N	Y	Y	N	N	N	Y
Chevron	3.7%	Y	N	N	N	N	Y	Y

The display below tabulates the 22 employer examples in relation to their estimated level of trip reduction impact -- high (>30 percent), medium (15 - 30 percent), and low (<15 percent) -- and in relation to the number of employees, defined as small (<1,000), medium (1,000 - 2,500), and large (>2,500). What seems evident in this display is that -- while none of the firms is truly "small" -- certainly trip reduction impact does not increase with added size. In fact, the highest performance is associated with the small employers and the smallest impact associated with the really large employers.

	EMPLOYER SIZE		
Program Net Trip Reduction	**Small ≤1000**	**Medium 1000 - 2500**	**Large ≥2500**
>30%	2	3	1
15 - 30%	3	3	3
<15%	1	3	3

2) Site Location & Density

Another popular belief is that TDM success is related to the conditions facing the employer at the site. Specifically, logic states that if a site is located in a higher-density area where parking is scarce and transit service is good, then it will be easier to reduce vehicle trips.

Obviously, if parking supply is restricted and carries a cost, there is a definite deterrent to driving and an in-place basis for the employer to further manage the price and allocation of parking. And if good transit service exists, shifts of employees to transit is highly efficient in reducing vehicle trips. Indeed, Central Business District sites like Travelers, San Diego Trust and Savings, and ARCO, have considerably higher rates of non-SOV use, and particularly transit use, than the other examples. However, what appears to be much more than the environment and starting trip rate is the set of measures built into the program. State Farm, for example, boasts one of the worst environments for trip reduction -- a suburban business park with unrestricted on-site parking and no transit service. However, it managed to attain a 30.4 percent trip reduction *relative to its peers* by applying the appropriate incentive actions to change behavior, even though its ultimate modal split is not nearly as impressive as its downtown counterparts.

As shown in the display below, ***the level of trip reduction performance is not substantially influenced by the density of the location of the employment site.***

	LOCATION DENSITY		
Program Net Trip Reduction	Low	Medium	High
>30%	2	3	1
15 - 30%	3	2	4
<15%	5	2	0

3) Employer Support Measures

There is little argument that a good TDM program which is accepted by employees can generally be linked back to solid backing and support by employers. In order for employees to consider alternative ways of commuting, they need to be introduced to the options that are available, be provided with ample information on how to use those alternatives, and then be encouraged by the employer to use the alternative. Examples of these types of measures include:

- *Employee Transportation Coordinator:* To provide information in a responsible personalized fashion, and continue to encourage employees to try new methods.
- *Marketing, Information and Promotions*: Newsletters, posters, fairs, campaigns and other media to inform employees about options and stimulate their use.
- *Guaranteed Ride Home*: Assurance that the employee will not be "trapped" at the site if an emergency or special situation develops.
- *Rideshare Matching:* Active or passive systems to facilitate matching.
- *Bike Lock-up, Shower and Changing Facilities:* An important element for a small portion of the travel base.

It becomes quite clear when reviewing the case studies that active support elements are in place at most of the sites; in other words, most employers are actively behind their programs. At the same time, ***it becomes clear that programs that rely only on these methods have very little impact on travel.*** That is because these methods are important in a supporting role to TDM, but are not the instruments that, in themselves, actually change behavior. As seen below, programs that rely heavily on Marketing or Support actions alone have earned some of the lowest trip reduction impacts, while sites with high impacts have not overly relied upon these measures.

Program Net Trip Reduction	General Marketing and Support Measures		
	Low	Medium	High
>30%	5	1	0
15 - 30%	3	3	3
<15%	1	1	5

4) Alternative Work Hours

Flexibility in work hours can be a benefit or liability to a TDM program. Most of the employers in the study group offer some measure of flexibility in work hours. In some instances, employees are permitted flexibility in order to better meet the requirements of rideshare or transit schedules. In other instances, employers allow employees freedom in work hours in order to have fewer of them arriving at a concentrated time. This practice is often used to help an employer meet the terms of a peak hour trip reduction ordinance, the type of which is common in the outlying counties of the San Francisco Bay Area. Data suggest that employees who travel outside the peak period are much more likely to drive alone; hence, the practice reduces a peak hour congestion problem, but may not contribute to travel efficiency, such as may be critical under other legal mandates, like air quality.

Note in the display below that seven of the eight employers whose programs placed a strong reliance on shifting work hours saved some of the lowest trip reduction impacts; meanwhile, 11 of the 14 employers that did not use alternative hours extensively were among the highest impact performers.

Program Net Trip Reduction	Alternative Work Hours	
	No	Yes
>30%	5	1
15 - 30%	6	3
<15%	3	4

Moderately Important Factors

1) Legal Requirement

It is important to note that most of these programs were stimulated by a legal requirement. Except for unusual circumstances (generally driven by economics), employers will not take steps to seriously manage employee travel on their own. This is due to both concerns about competitive disadvantage as well as misunderstanding of the measures themselves. Only a few of the studied programs were initiated by the employer, as either an economic measure or as a personnel measure. In those instances when it was an economic issue, such as with Travelers, Hartford Steam or ARCO, parking expense was the primary motivating factor, management of which put the firm on the fast track to an effective TDM program. Where it was more of a personnel issue, such as with 3M, the actions and their effects were much more conservative.

As shown in the display below, the presence of a legal requirement has a seeming inconsistency with the level of impact. Indeed, five of the top six sites, and 12 of the top 15, may have their success linked to an external legal requirement. However, six of the seven poorest sites also occurred under a legal requirement. Is a legal requirement important or not?

	Legal Requirement	
Program Net Trip Reduction	No	Yes
>30%	1	5
15 - 30%	2	7
<15%	1	6

While it is important to stimulate employer participation through a legal requirement, some instruments are obviously much more effective than others. Trip reduction ordinances that set no goal (as with Chevron), which set only a peak hour requirement (as with AT&T/Hacienda Business Park), or which provide no prescriptions for actions or consequences for failed performance will not on their own cause an employer to implement a successful program. So while a legal requirement is frequently a necessary condition, it is not sufficient -- without further direction or penalty -- to cause an effective program.

2) Support of Transit

For those employment sites where good pre-existing transit service was available, and the TDM program capitalized on that opportunity with appropriate encouragement and incentives, transit played a key role in the efficiency and performance of the program. Travelers, Hartford Steam Boiler, and NRC are good examples. However, ***when the employer was located in a site where transit did not constitute a viable option, either encouraging employees to use it with marketing and subsidies, or attempting to develop a new service through special arrangements (shuttles, subscription bus) has generally not been effective.*** This is certainly the case for most sites outside the CBD.

These relationships are demonstrated in the display below. Note the number of sites where transit received high support and paid back high trip reduction results. But note also the situations where support was high and performance was low, and in contrast, sites where transit support was low but trip reduction performance was high.

	EMPLOYER SUPPORT OF TRANSIT		
Program Net Trip Reduction	Low	Medium	High
>30%	2	1	3
15 - 30%	0	4	5
<15%	2	3	2

3) Support of Vanpooling

Some firms who have placed a concentrated effort behind vanpooling have been able to place a substantial number of their employees in vanpools. And, like transit, because of the number of people who can be carried in a single vehicle, the leverage this mode presents in reducing vehicle trip rate is attractive. However, many firms who have concentrated on vanpool programs have also developed a rather narrow vision toward other modes and options. ***As a result, they either realize most of their success through vanpooling share, or have unbalanced programs with low overall impact.*** Good examples are 3M, Allergan and Chevron, which are heavily invested in vanpooling, but which have modest overall performance. This does not suggest that vanpooling is ineffective -- quite the contrary -- or that vanpooling is a cost-thrifty approach; these employers place considerable staff and financial resources behind these programs, because the programs also project the company's image. As may be noted in the display below, several of the firms with high net vehicle trip reduction scores have substantial vanpool shares without apparently engaging in well-rounded programs. These firms, like Pacific Bell, have achieved most of their success because of the long commutes that their corporate relocations have imposed on their employees. These employees find short-term refuge in a vanpool, but trends show that, without a comprehensive set of supporting measures, these travelers tend to find other locational and modal opportunities over time. In Pacific Bell's case, the work force has adjusted so that more employees live closer every year and drive alone.

The display of effort vs. performance below reveals the same type of relationships as with employer support of transit: if the environment is right for vanpooling, and/or it is supported by appropriate incentives, a TDM program which emphasizes vanpooling can be very effective. However, note below also that four programs have emphasized vanpooling and achieved low impacts, or have achieved high impacts with little or no utilization of vanpooling.

	EMPLOYER SUPPORT OF VANPOOLING		
Program Net Trip Reduction	**Low**	**Medium**	**High**
>30%	3	1	2
15 - 30%	2	3	4
<15%	2	1	4

Most Important Factors

1) Support of Carpooling

While carpooling may seem to offer a much more modest potential as a trip reduction strategy relative to vanpooling or transit, and may require more of a personal investment by travelers, carpooling appears to be a common element of success in most of the case studies. Even sites in high-density downtown locations or which had major transit or vanpool programs had substantial numbers of employees using carpools. The reason for this is probably that carpooling represents the most ***flexible*** alternative to the traveler, in terms of commitment to schedule and in replication of the door-to-door convenience of the private SOV. ***Those employers who attempted to get the most from this strategy, through concerted incentive and other support measures, ranked highest in overall trip reduction.***

As seen in the display below, employers who placed high support behind carpooling showed the highest impacts among the sample, while no employer who failed to support carpooling realized the highest level of trip reduction performance.

Program Net Trip Reduction	Employer Support of Carpooling		
	Low	Medium	High
>30%	0	1	5
15 - 30%	1	3	5
<15%	2	5	0

2) Restricted Parking

Parking is critical in traveler decision making. If parking is unrestricted, the traveler will generally opt to drive alone. On the other hand, if parking is restricted and there is competition for spaces, there is instant pressure to find and use alternatives. There is also a basis for the employer to enact measures to better allocate and use that parking, either through preferential/reserved treatment, or through pricing. ***Those sites with the best TDM program results are those where parking was in some way restricted or managed.*** In contrast, those at the bottom of the list -- 3M, Allergan and Chevron (restrictions at UCLA actually not significant) -- had conventional, unrestricted parking. Note in the display below that 14 of the top 15 sites had restricted parking.

Program Net Trip Reduction	Restricted Parking	
	No	Yes
>30%	1	5
15 - 30%	0	9
<15%	4	3

Many sites with restricted parking provided either reserved or close-in parking for carpools and vanpools. If this benefit provides a significant time savings to the beneficiary (or weather protection in severe climates), it can induce mode shifts. However, many employers who implement preferential/reserved parking spaces for pools do so in a token manner, such that the user receives no material time benefit, other than the prestige of a reserved space. Travelers Insurance, as a good contrast, gives its few on-site spaces to pools, and makes SOV users park off-site.

3) Parking Charges

Perhaps no action has a greater single effect on discouraging the use of SOVs and increasing the attractiveness of alternatives than placing a price on parking. Most of the top firms in the list not only have restricted parking, but impose some charge on the use of that parking. Revenues derived from the fees are generally used to support the other program measures, so the strategy has a dual appeal to the employer. Note in the display below that 12 of the 15 sites charged for parking, and those that do not charge are at the bottom of the list.

Program Net Trip Reduction	PARKING CHARGES	
	No	Yes
>30%	1	5
15 - 30%	2	7
<15%	5	2

One may wonder, therefore, why two cases -- UCLA and COMSIS -- have parking charges but fall at the bottom of the list; in UCLA's case, the parking charges are extremely modest, and in fact much less than the market rates in the general area. In the case of COMSIS, not all parking is priced, and those given free parking privileges in the building all drive alone. But at the same time, because parking in the surrounding area is priced, a high proportion of those employees who face parking charges have found alternative ways to commute. COMSIS's modal split id attractive but its net trip reduction is low because it is being compared to an area where most firms also employ some measure of TDM.

4) Financial Incentives

Perhaps just as valuable as the parking charge, ***and certainly much easier to gain acceptance for,*** *are financial incentives to those who do not drive alone*. As shown in the display below, 14 of the top 15 firms employed some type of subsidy measure at either a "medium" or "high" level of significance. The low impacts of those who did not use subsidies stand in contrast.

The most common forms of subsidy are providing discounted or free parking to pools, and providing subsidized passes to transit users. When subsidies are offered, and they are tangible in receipt and value, they seem to have a profound effect on mode choice. Perhaps the best example is State Farm, which despite a remote suburban location, abundant parking and no transit service, achieved a 30 percent trip reduction almost exclusively through progressive (higher by occupancy) daily subsidies to poolers. Other firms have experimented with indirect subsidies, such as days off, lotteries, or annual bonuses, but they seem to be much less effective than the direct, frequent transfer of cash from employer to user.

	FINANCIAL INCENTIVES		
Program Net Trip Reduction	Low	Medium	High
>30%	0	1	5
15 - 30%	1	5	3
<15%	4	3	0

3.2.5 Summary

Eleven factors have been reviewed in terms of their importance to effective employer-based TDM programs. In summary, their importance may be categorized as follows:

LEAST IMPORTANT	Employer Size Location Density General Marketing and Support Alternative Work Arrangements
MORE IMPORTANT	Legal Requirement Support of Transit Support of Vanpooling
MOST IMPORTANT	Support of Carpooling Financial Incentives Restricted Parking Parking Charges

Beyond this identification of key factors, this case study review of empirical evidence helps sharpen understanding of two very important challenges related to the potential of TDM:

- Is TDM an effective strategy for changing individual travel behavior?
- Is TDM an effective strategy for combatting traffic, reducing emissions and providing mobility at an areawide level?

This section has presented strong empirical evidence that TDM programs, when properly conceived and implemented, can have a significant impact on travel choice and vehicle trip making. The majority of programs reviewed in the analysis had *net vehicle trip reduction* achievements of 20 percent or more, with a number of them above 40 percent. These results are neither an accident nor a peculiarity of measurement; the respective sites implemented programs of actions that directly impacted the basis upon which their employees decided how to travel. By changing those underlying factors in strategic ways with special offerings, *bona fide* changes in behavior have occurred. The case study review helps to both quantify the level of potential trip reduction as well as identify the factors that are important (or not important) in causing changes in travel behavior, and in a fundamental way, confirm the basic principles of travel theory.

Some professionals have raised doubt as to whether TDM could be effective at a *site* level, and then have extrapolated that argument to challenge whether TDM can be effective and meaningful as an *area-wide* solution. Results from case studies such as these certainly put to rest the first doubt, showing that TDM success at a site level can be documented and may be directly related to specific program measures. The remaining challenge, then, is whether TDM is a credible area-wide transportation strategy.

The evidence that would controvert TDM as an effective area-wide strategy is based on numerous existing programs around the country that have taken an area-wide approach to TDM. Many of these efforts are associated with the formation of Transportation Management Associations, which has been a popular institutional mechanism to grapple with complex transportation problems and engage the support of the private sector. Because virtually all of these TMA efforts have involved voluntary cooperation by employers or developers, with no substantial performance penalties, they cannot be associated with measurable changes in travel. Most provide good forum for discussing transportation issues and considering menus of actions, but none have had the technical guidance or legal clout to cause them to identify and implement decisive actions. Thus, these programs have emphasized marketing approaches and advocacy positions, and have not been instruments of change. A number of area-wide programs were reviewed by this study in reaching this conclusion. The reader is also referred to the following studies from a thorough review of national TMA experience with TMAs and area-wide programs:

- ***Regional Mobility Program Review: Phase II -- R&D Projects***: COMSIS Corporation and Booz-Allen Hamilton for the Urban Mass Transportation Administration, Sept. 1991.

- ***Transportation Management Associations in the United States: Final Report***: Georgia Institute of Technology, for the Federal Transit Administration, May 1992.

Legal initiatives, such as trip reduction ordinances (TROs), cause a somewhat greater resolve to bring about change, but only to the extent of the specific requirements, prescriptions, and enforcement as discussed at the end of the section (Part II).

As a result of these two popular approaches (TMAs or TROs) to implementing TDM on an area-wide level, the great majority of employers in the affected area either take no action, insufficient action, or ill-advised action to change travel behavior. Thus, what we observe to date are isolated examples of solid programs and performance. This does not defeat the potential for TDM: it merely indicates that we have not yet developed the mechanism by which more than a handful of firms can be led to the right solution. Much of the reason for this has been a misunderstanding of the nature and potential for TDM. This lack of information has caused transportation and elected officials, and certainly private officials acting individually, to opt for conservative approaches with limited risk and limited impact.

The next section begins to offer insight as to how the growing base of information and tools on TDM can lead to the development of more broad-based and effective programs.

3.3 PROJECTING THE EFFECTIVENESS OF TDM WITH ANALYTIC TOOLS

3.3.1. Overview

3.3.1.1. Need for Analytic Tools

While the case study examples in the previous section provide important evidence regarding the potential of TDM programs, they also serve to identify a need for another type of information to support ***practical TDM planning and program development.*** In particular, the stage is set for special tools and procedures which can ***forecast*** the effects of TDM on a more comprehensive basis. These tools and their use is the subject of this section.

Case studies give credibility to TDM. However, it is impossible to use a small number of individual case studies (even if that number were several hundred!) to address the following types of practical questions and considerations that arise when investigating TDM alternatives:

- What happens when the site to be considered has *different starting conditions* than the case study example(s)?
- What happens if it is desired to examine a different *package* of actions, or try *different levels of stringency* of particular measures than were used in the case studies?
- How can the effectiveness of TDM be estimated *at an area-wide level,* with different combinations of employers (size and type) under different degrees of *regulatory requirement*?

Because of these limitations, planners and researchers often resort to statistical methods, or *models,* to "fill in the gaps" and project from a known situation into a new, unknown situation. Unfortunately, the types of modeling tools traditionally used by planners, in order to be accurate enough to satisfy detailed planning requirements, become too complex (in data or operation) and time consuming to be useful for TDM analysis. These conventional models also do not address many TDM strategies or related issues of concern.

To address this special information need, a **TDM Evaluation Model** which was developed earlier by COMSIS Corporation and R.H. Pratt, was adapted as a separate product under this contract as an aid to professionals involved in TDM planning and evaluation. This model is a software program that operates on a microcomputer, and permits assessment of the travel impacts of most of the known TDM strategies, alone or *in combination* as realistic program packages. The TDM measures may be targeted at a single employer or site, or to an entire geographic travel market. The model may be obtained through the Federal Highway Administration as a separate product for use in local planning analyses, and indeed, many readers may find the model extremely relevant to their planning needs. A complete User's Guide accompanies the model.

Here in the Main Report, the TDM Model has been used to begin to project the effects of the various TDM strategies in ways that go beyond the limits of the empirical case studies. The model has been set up to reflect different implementation environments where TDM measures might be implemented. The model has then been applied to a wide range of TDM actions, and the reader is provided with summary displays -- primarily charts and graphs -- that indicate what level of impact might be expected under these conditions. The presentation is structured to first look at *individual* strategies, to establish a basic reference frame, and then in terms of strategy *packages*, such would occur in realistic programs.

3.3.1.2 Description of TDM Evaluation Model

A brief description is offered of the TDM Evaluation Model that has been used to generate the impacts which are presented in this section. A more complete description is provided in the actual User's Guide which accompanies the model. This description serves mainly to acquaint the reader with the key assumptions and calculations that underlie the model's operation and the resulting impact estimates.

- **Application and Source Data**

The TDM model may be applied to either an individual site or an extra subarea. In the case of an individual site, the model requires a measure of the modal split for the travel population, as typically determined through employee surveys. For area-wide applications, the base data typically consists of "trip tables", (matrices of person and vehicle trip flows from origin to destination), such as are produced by the traditional 4-step planning process used by most planning organizations.

- **Model Outputs**

For each strategy or group of strategies evaluated in the TDM model, the impacts are measured in terms of before-and-after modal split, person/trips, vehicle trips, and vehicle miles of travel (VMT).

- **Calculation of Impacts**

The TDM model makes its predictions of travel change from one of two mechanisms: a logit "mode split" model, or look-up tables derived from empirical relationships.

Many TDM actions can be reduced in nature to effects on the ***time or cost of travel.*** For these types of actions, the travel impact is predicted with a modal split equation, of the *disaggregate logit* form, such as is used for mode choice analysis by most metropolitan planning organizations. The values or "weights" in this equation, as applied in this test, have been melded from over 20 different metropolitan area models across the country.

Those TDM actions that cannot be reduced to time or cost terms are dealt with by relation to empirical evidence. Look-up tables have been developed within the TDM model package that indicate the probable change in modal split if one of these actions is invoked at a particular level. Employer support of carpool, vanpool and transit programs are handled in this manner, as are alternative work schedules, drawing upon the extensive review of literature and case studies which occurred under this study.

- **Regulatory Environment**

The implementing agent for a number of TDM actions is *the employer*. The effectiveness of a TDM action implemented through employers depends in varying degrees upon the type of action, the type and size of employer, and the existence of any regulatory pressure on the employer to implement and achieve success with the action. The TDM model approximates the implications of regulatory requirements by:

(1) First distinguishing actions that are implemented by employers;

(2) Tying the impacts of particular strategies to the type and size of employer;

(3) Relating the input data to an employment distribution, which then partitions the travel market into different employment subgroups within which TDM effects are known to vary; and

(4) Allowing the user to select a "participation level" when assessing an employer-based action, simulating the degree to which employers are likely to apply a particular TDM action under regulatory conditions ranging from "Voluntary" to "Mandatory".

3.3.1.3 Setting Test Conditions

This section of the report uses the TDM Model to project what travel impacts would result if various TDM measures were put into place under differing circumstances pertaining to either the measure itself or the background setting. The following are important factors related to setting which must be established before projections of impact can be made:

- **Target Population**

TDM actions are mainly directed at work travel, because of commuting's contribution to peak period traffic congestion, and because the repetitive nature of commute travel lends itself to mode and time of day substitutes. Therefore, these projections relate. In this analysis, commuters are the target for the TDM strategies.

Also, we are mainly concerned about TDM potential at an area-wide level. Hence, strategies are applied to an assumed travel population that corresponds to a typical distribution of employers by type (office and non-office) and size (small, medium, large and very large). This distribution is derived from national census data.

- **Setting**

The change in behavior which the TDM Model forecasts in response to a set of TDM actions depends on the starting modal split. Travel demand research and forecasting studies show that in travel markets where existing rates of single-occupant vehicle (SOV) use are high and use of alternatives like transit and ridesharing are low, a policy to encourage use of the alternatives will have less effect than if same policy were applied to in an environment where the starting shares for these alternatives are higher (this is reflected in the "S-shaped" nature of the "logit curve.") Therefore, to make an assessment of the value of a particular TDM action, one must first account for the starting conditions that describe the particular setting.

In an effort to provide relevant look-up displays on TDM impacts, "setting" has been defined in terms of three different environments. These environments are described in terms of four characteristics:

- *Density*: the environments represent a low-density suburb, a medium density activity center, and a high-density regional CBD or corridor.

- *Modal Split*: the proportion of trips currently made by SOV, transit and ridesharing.

- *Average Vehicle Occupancy (AVO)*: a commonly-used measure of travel efficiency obtained by dividing the number of persons *traveling in private vehicles* by the number of private vehicle trips.

- *Average Vehicle Ridership (AVR)*: also a measure of efficiency like AVO above, this measure is being used more commonly in traffic mitigation and air quality analyses. AVR is obtained by dividing *all person trips* by the number of private vehicle trips, and is thus a larger number which characterizes the entire population's need for vehicles, and not just the rate at which private vehicle users are occupying private vehicles.

The three settings are defined as follows:

	(1) Low Density Suburb	(2) Activity Center	(3) Regional CBD/Corridor
Modal Split			
SOV	85%	66%	41%
Transit	7%	16%	30%
Rideshare	8%	18%	29%
Avg. Veh. Occupancy	1.05	1.20	1.35
Avg. Veh. Ridership	1.13	1.35	1.90

These three hypothetical settings do a reasonably good job at distinguishing the segments or important "break points" in the logit curve, i.e., where the results predicted by the model change substantially from setting to setting. And, almost as important as the starting modal shares that define these three settings is the fact that the two non-SOV modes -- Transit and Ridesharing -- can take on substantially different values and still result in the same Average Vehicle Ridership. If these shares are different, with the extremes being one where ridesharing makes up the primary alternative mode and the other being where transit is the primary alternative mode, then the applied TDM actions will produce substantially different results.

To account for this, an additional set of modal share prototypes has been developed for each area, *where the same AVR has been represented by different relative mixtures of rideshare and transit.* These are referred to as Mode Neutral (modes in approximate balance), Rideshare Heavy (carpool + vanpool greater than 50 percent of all alternative mode use) and Transit Heavy (transit greater than 50 percent of all alternative mode use). These are expressed in the following table in terms of both the AVR, which is mode independent and remains constant, and AVO, which changes to reflect relative levels of private vehicle use (lower where transit use is greater). Also shown is the nomenclature (e.g., AVR 1 EV) for the nine different AVO settings, as they will be presented in the various tables and displays.

	Low-Density Suburb	Activity Center	Regional CBD
AVR	1.12	1.35	1.90
AVO = "Mode Neutral"	1.05 **AVR 1 EV**	1.20 **AVR 2 EV**	1.35 **AVR 3 EV**
AVO = "Transit Heavy"	1.02 **AVR 1 TR**	1.04 **AVR 2 TR**	1.04 **AVR 3 TR**
AVO = "Rideshare Heavy"	1.10 **AVR 1 CP**	1.24 **AVR 2 CP**	1.60 **AVR 3 CP**

- **Employer Participation**

For those strategies implemented by employers, degree of regulatory pressure is directly related to bottom-line performance. Generally, when these measures are tested in this analysis, we will examine the likely effects under **voluntary** participation, **full mandatory** participation, and **maximum** participation (which is the theoretical 100 percent participation upper limit).

3.3.2 Projected Effectiveness of Individual TDM Strategies

This section provides forecasts of the potential impact on travel of each of the major types of TDM strategies, obtained by applying the TDM model to selected starting conditions which are outlined below. The purpose of this information is to provide the reader with:

- A benchmark of the impact of the various TDM strategies individually;
- An estimate of the effectiveness of these strategies at different levels of application in different environments; and
- An estimate of the effectiveness of the strategies as compared to one another.

The information offers the reader a "sensitivity analysis" of the individual measures, such as cannot be easily obtained from empirical examples where strategy effects are confounded by unique incorporations of measures and site factors. It should be emphasized, however, that the real effectiveness of TDM actions is realized when individual measures are grouped into practical programs, where the strategies reinforce one another. The reader is warned not to try to estimate the effects of groups of strategies by building up the estimates provided on the individual measures in this section; their effects are not additive, and it is possible to make a gross miscalculation of impact by doing so. A later section (3.3.4) begins to show the results of TDM "packages", or "grouped actions."

The TDM measures considered in this section are grouped as follows:

- **Improved Alternatives:** Actions taken by employers to improve the basic awareness of alternatives by employees, and to enhance their attractiveness in supportive ways.

- **Incentives and Disincentives:** Both time and cost incentive and disincentive measures applied by government/transportation agencies or employers to change the relative economics between the SOV and alternative modes and increase the attractiveness of the alternatives.

- **Alternative Work Schedules:** Actions which can be taken by employers to either shift the time of travel or reduce its frequency of occurrence.

3.3.2.1 Improved Alternatives

For most travelers, the private vehicle is the standard of comparison. It offers door-to-door convenience and the ultimate in personal choice and discretion. Modern land forms and business practices are built to enhance, rather than discourage its use. Therefore, if we want travelers to consider mobility in terms other than driving alone -- it is necessary to enhance the attractiveness of the immediate alternatives, realizing that those alternatives are up against some fairly tough competition.

There are three primary ways of enhancing the attractiveness of alternatives:

- Change the *service configuration* or pattern of the alternative (or the SOV) to improve the *relative* performance of the alternative, most particularly through improved travel time.

- Change the *cost structure* such that the alternative is more attractive in economic terms than the SOV.

- Provide various types of *supporting and informational* programs to users of alternative modes to either make them immediately more attractive or to overcome some of the obvious impediments to their routine use.

The first two of these actions are covered in the next section on incentives and measures, known generally as ***employer support measures***, to encourage higher rates of alternative mode use.

Employers can take a number of steps to enhance the attractiveness of alternative modes to their employees. They can:

- Provide general corporate support, encouragement and endorsement of employee usage of alternative modes;
- Provide improved information to users on the characteristics and availability of the options;
- Provide matching services for carpool or vanpool users to learn of other rideshare candidates;
- Provide a transportation coordinator (on a part or full-time basis) to counsel and encourage employees on travel options;
- Provide flexible work schedules (not flex-time as such) to enable transit or rideshare users freedom to adapt to the schedule demands of those modes;
- Provide special parking privileges to HOV users;
- Provide administrative and background financial support to alternative mode programs (especially vanpooling);
- Offer a guaranteed ride home or similar back-up options to employees who forsake personal vehicles and may be "stranded" at the site.

These are but a few of the supportive actions that employers can take to encourage employees into using alternative modes. In general, these actions can be regarded as:

- Very important in providing the starting basis for employees to consider use of alternative modes;
- Somewhat less important than tangible time or cost incentive actions in actually causing changes in behavior, which will be assessed later.

Considerable evidence exists to begin to approximate the likely effects of these employer support programs if implemented under different regulatory conditions. Primary sources for the projected levels of impact are the results from extensive TDM program evaluation and tracking efforts in the Seattle area and Southern California's Regulation XV experience; "support" measures were the primary instruments of employer programs in these areas. The case studies in Section 3.2 were also a contributing source to the development of the trip reduction factors in relation to employer support programs.

Figures 3.3-1 through 3.3-3, and Tables 3.3-1 through 3.3-3 provide illustration of the estimated impacts that these employer support program measures might be expected to have on travel. The first figure projects the effects of employer support of transit, while the second deals with carpool support programs, and the third deals with vanpool support programs.

The measure of travel impact that will be used universally through this section is *percent reduction in private vehicle trips*, which is the measure of performance that was used in evaluating the case studies in Section 3.2. Percent trip reduction is a versatile measure, which is the primary objective that most TDM programs are trying to obtain. While it may not be as transparent a measure as modal split, in terms of the effect it is having on individual modal choices, it is a very good barometer of overall effectiveness and efficiency. For those whose performance measure is Average Vehicle Ridership, or AVR (total person trips divided by total private vehicle trips), *percent trip reduction* can be used to derive changes in AVR as well.

The figures indicate the level of trip reduction impact that would be expected to occur if these Employer Support programs were implemented at a specified "Level" of effort. Four different levels of effort have been developed for each modal program, ranging from Level 1 (minimal) to Level 2 (moderate), to Level 3 (good), to Level 4 (best). Each of these levels has specific program elements; many of the elements are common across programs, i.e., they would be offered to carpoolers, vanpoolers, or transit users, while others are clearly specific to the characteristics/needs of the particular mode.

Impacts for each program would also be expected to depend upon the particular setting in which they were implemented, as regards:

- **Starting Point,** in terms of AVR level (under 1.20, 1.21 to 1.50, and over 1.50).
- **Modal Balance,** i.e., whether the AVR is comprised of a modal split that is initially tilted in favor of transit use, rideshare use, or is mode neutral.
- **Regulatory Requirement,** i.e., whether employers would be implementing these efforts under Mandatory or Voluntary conditions.

Employer Transit Support Programs

Figure 3.3-1 shows the effects of employer support of transit. The four different *levels of effort* are defined as follows:

Level 1: Provision of a transit information center on site, plus a 1/4-time transportation coordinator.

Level 2: Level 1 plus adoption of a policy of schedule flexibility to allow employees to synchronize work schedules with transit schedules.

Level 3: Level 2 plus provision of on-site transit pass sales (does not include employer discounting of transit fare), and increase in the effort of the transportation coordinator to part-time.

Level 4: Level 3 plus adoption of a guaranteed ride home program, and provision of a full-time transportation coordinator.

The first column of Figure 3.3-1 indicates the level of trip reduction impact if these program measures were implemented under "Full Participation", an ideal environment *where all employers would participate,* which is unlikely to happen and hence represents the theoretical upper limit. Were this the case, a program of transit support measures would be likely to increase employee use of transit and reduce vehicle trips by 0.2 percent to 2.2 percent in the low AVR environment, from 0.2 percent to 2.7 percent in the medium AVR environment, and from 0.2 percent to 3.6 percent in the high AVR environment. Obviously, if employee mode split is initially tilted in favor of transit, the effects are greater than if it is initially tilted in favor of ridesharing, or if the balance is neutral.

Of course, it is unlikely that **all employers** would ever participate in such a program, so the middle portion of the figure shows the likely effects if these program actions were implemented under a typical **mandatory** condition, where employers were compelled to make best efforts by law. The assumption is that some will still not participate, or not participate as earnestly, as the ideal. The results are subsequently lower, with trip reduction impacts in the 0.2 - 2.0 percent range for the low AVR group, 0.2 - 2.4 percent range for the medium AVR group, and in the 0.2 - 3.3 percent range for the high AVR group.

If no legal requirement is present, but employers are simply *requested* to participate, then a **voluntary** situation exists, and one might expect the level of impacts shown in the last third of the figure: trip reductions in the 0.0 - 0.5 percent range for the low AVR and the medium AVR groups; and in the 0.0 - 0.7 percent range for the high AVR group.

Figure 3.3 - 1
Employer Transit Support Programs
Vehicle Trips Percent Reduction

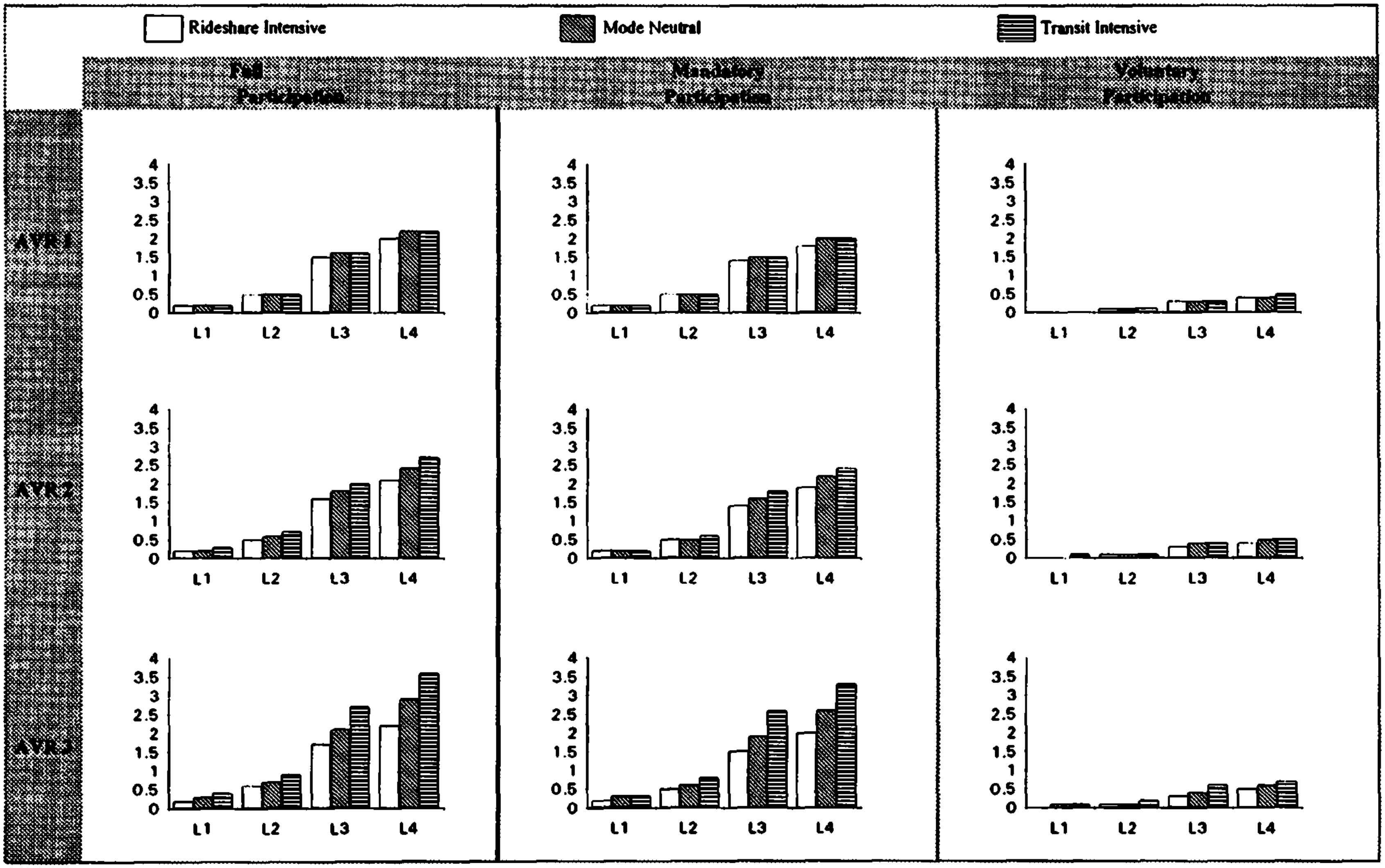


Table 3.3-1
Employer Support of Transit

Table Shows Percent Vehicle Trip Reduction

AVR Setting	*Starting Mode Shares*					*Maximum Participation*				*Mandatory Participation*				*Voluntary Participation*			
						Level of Support				*Level of Support*				*Level of Support*			
	AVR	*DA*	*TR*	*CP*	*VP*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
AVR1 CP	1.13	79.5	0.5	18.3	1.7	0.2	0.5	1.5	2.0	0.2	0.5	1.4	1.8	0.0	0.1	0.3	0.4
AVR1 EV	1.13	85.0	7.0	7.3	0.7	0.2	0.5	1.6	2.2	0.2	0.5	1.5	2.0	0.0	0.1	0.3	0.4
AVR1 TR	1.13	86.6	9.0	4.1	0.3	0.2	0.5	1.6	2.2	0.2	0.5	1.5	2.0	0.0	0.1	0.3	0.5
AVR2 CP	1.35	60.2	5.0	31.2	3.6	0.2	0.5	1.6	2.1	0.2	0.5	1.4	1.9	0.0	0.1	0.3	0.4
AVR2 EV	1.35	66.2	16.0	16.1	1.7	0.2	0.6	1.8	2.4	0.2	0.5	1.6	2.2	0.0	0.1	0.4	0.5
AVR2 TR	1.35	73.7	25.0	1.1	0.2	0.3	0.7	2.0	2.7	0.2	0.6	1.8	2.4	0.1	0.1	0.4	0.5
AVR3 CP	1.90	30.7	10.0	53.1	6.2	0.2	0.6	1.7	2.2	0.2	0.5	1.5	2.0	0.0	0.1	0.3	0.5
AVR3 EV	1.90	41.3	30.0	25.8	2.9	0.3	0.7	2.1	2.9	0.3	0.6	1.9	2.6	0.1	0.1	0.4	0.6
AVR3 TR	1.90	50.8	45.0	3.8	0.4	0.4	0.9	2.7	3.6	0.3	0.8	2.5	3.3	0.1	0.2	0.6	0.7

Employer Carpool Support Programs

Figure 3.3-2 shows the effects of employer support of carpooling. The four different levels of effort are defined as follows:

Level 1: Provision of information on carpooling opportunities (tied in with area-wide matching efforts) and general promotion of carpooling on-site, plus a 1/4-time transportation coordinator.

Level 2: Level 1 plus in-house carpool matching services and/or personalized carpool candidate get-togethers.

Level 3: Level 2 plus preferential parking privileges for carpools (reserved, enclosed, or particularly convenient), adoption of a policy of work-hours flexibility to allow employees to conform to carpool schedules, and an increase in the effort of the transportation coordinator to part-time.

Level 4: Level 3 plus adoption of a guaranteed ride home program, and provision of a full-time transportation coordinator.

The first column of Figure 3.3-2 indicates the level of trip reduction impact if these Carpool Program measures were implemented under full participation, mandatory and voluntary conditions.

Under the ideal of Full Participation, a program of carpool support measures would be likely to increase employee carpooling and reduce vehicle trips by a range of 0.2 percent to 2.8 percent for the low AVR environment, by a range of 0.2 percent to 3.0 percent for the medium AVR environment, and by a range of 0.0 percent to 2.4 percent for the high AVR environment. Again, if employee mode split is initially tilted in favor of a particular mode, greater returns will be realized to that mode; hence, the carpool-heavy AVR groups show the greatest trip reduction benefits. *The reviewer will note that the higher AVR groups show smaller trip reduction benefits than the lower AVR groups -- in contrast to the transit programs above; this is because at the higher AVR levels, carpooling efforts are attracting some riders from transit, which in these markets is less efficient from a vehicle trip reduction point of view.*

Under **mandatory** conditions, trip reductions range from 0.2 percent to 2.6 percent for the low AVR group, 0.1 percent to 2.7 percent for the medium AVR group, and 0.0 percent to 2.2 percent for the high AVR group. Under a **voluntary** situation, the level of trip reduction would range from 0.0 percent to 0.6 percent for the low AVR and the medium AVR groups, and 0.0 percent to 0.5 percent for the high AVR group.

Figure 3.3 - 2
Employer Carpool Support Programs
Percent Reduction in Vehicle Trips

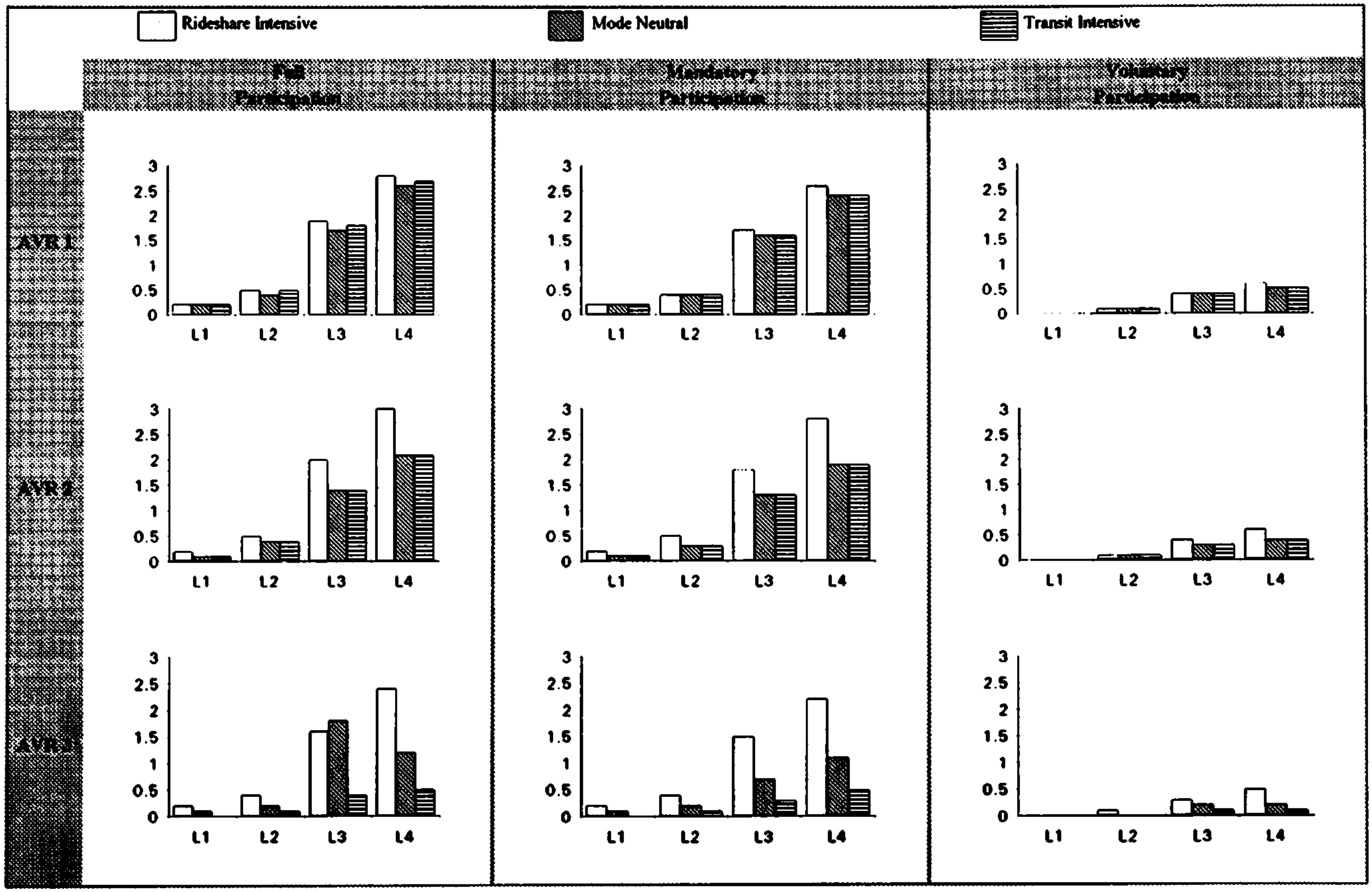


Table 3.3-2
Employer Support of Carpooling

Table Shows Percent Vehicle Trip Reduction

AVR Setting	*Starting Mode Shares*					*Maximum Participation*				*Mandatory Participation*				*Voluntary Participation*			
						Level of Support				*Level of Support*				*Level of Support*			
	AVR	***DA***	***TR***	***CP***	***VP***	***1***	***2***	***3***	***4***	***1***	***2***	***3***	***4***	***1***	***2***	***3***	***4***
AVR1 CP	1.13	79.5	0.5	18.3	1.7	0.2	0.5	1.4	2.8	0.2	0.4	1.7	2.6	0	0.1	0.4	0.6
AVR1 EV	1.13	85	7	7.3	0.7	0.2	0.4	1.7	2.6	0.2	0.4	1.6	2.3	0	0.1	0.4	0.5
AVR1 TR	1.13	86.6	9	4.1	0.3	0.2	0.4	1.7	2.6	0.2	0.4	1.6	2.4	0	0.1	0.4	0.5
AVR2 CP	1.35	60.2	5	31.2	3.6	0.2	0.5	2	3	0.2	0.5	1.8	2.7	0	0.1	0.4	0.6
AVR2 EV	1.35	66.2	16	16.1	1.7	0.1	0.4	1.4	2.1	0.1	0.3	1.3	1.9	0	0.1	0.3	0.4
AVR2 TR	1.35	73.7	25	1.1	0.2	0.2	0.4	1.7	2.6	0.2	0.4	1.6	2.4	0	0.1	0.4	0.5
AVR3 CP	1.9	30.7	10	53.1	6.2	0.2	0.4	1.6	2.4	0.2	0.4	1.5	2.2	0	0.1	0.3	0.5
AVR3 EV	1.9	41.3	30	25.8	2.9	0.1	0.2	0.8	1.2	0.1	0.2	0.7	1.1	0	0	0.2	0.2
AVR3 TR	1.9	50.8	45	3.8	0.4	0	0.1	0.4	0.5	0	0.1	0.3	0.5	0	0	0.1	0.1

<u>Employer Vanpool Support Programs</u>

Figure 3.3-3 shows the effects of employer support of vanpooling. The four different levels of effort are defined as follows:

Level 1: Provision of information on vanpooling opportunities (tied in with area-wide matching efforts and/or third-party vanpools), plus a 1/4-time transportation coordinator.

Level 2: Level 1 plus in-house vanpool matching services and/or personalized vanpool candidate get-togethers, plus non-monetary vanpool development activities, and adoption of a policy of work-hour flexibility to allow employees to conform to vanpool schedules.

Level 3: Level 2 plus offering financial assistance to vanpool development, including vehicle purchase loan guarantees, consolidated purchase of insurance (or self-insurance), startup subsidy (generally at least two forms of financial assistance), and additional assistance such as van washing and preferential parking privileges for vanpools (reserved, enclosed, or particularly convenient), plus an increase in the effort of the transportation coordinator to part-time.

Level 4: Level 3 plus adoption of a guaranteed ride home program, major financial assistance (such as employer purchase of vehicles with favorable leaseback, employer-supplied maintenance, fuel or insurance, or empty-seat subsidies), plus provision of a full-time transportation coordinator.

The first column of Figure 3.3-3 indicates the level of trip reduction impact if these Vanpool Program measures were implemented under full participation, mandatory and voluntary conditions. *It should be noted that the set of employer measures to support vanpooling involve substantially more commitment, in terms of financial involvement, than either of the other two programs; for this reason, employee response to vanpooling is projected to be higher relative to the other two modal programs.*

Under the ideal of Full Participation, a program of vanpool support measures would be likely to increase employee vanpooling and reduce vehicle trips by a range of 0.4 percent to 7.1 percent for the low AVR environment, by a range of 0.4 percent to 7.3 percent for the medium AVR environment, and by a range of 0.4 percent to 7.5 percent for the high AVR environment. Again, if employee mode split is initially tilted in favor of the mode that is being favored, greater returns will be realized; hence, the carpool-heavy AVR groups show the greatest trip reduction benefits.

Under **mandatory** conditions, trip reductions range from 0.3 percent to 6.5 percent for the low AVR group, 0.3 percent to 6.6 percent for the medium AVR group, and 0.3

Figure 3.3 - 3
Employer Vanpool Support Programs
Percent Reduction in Vehicle Trips

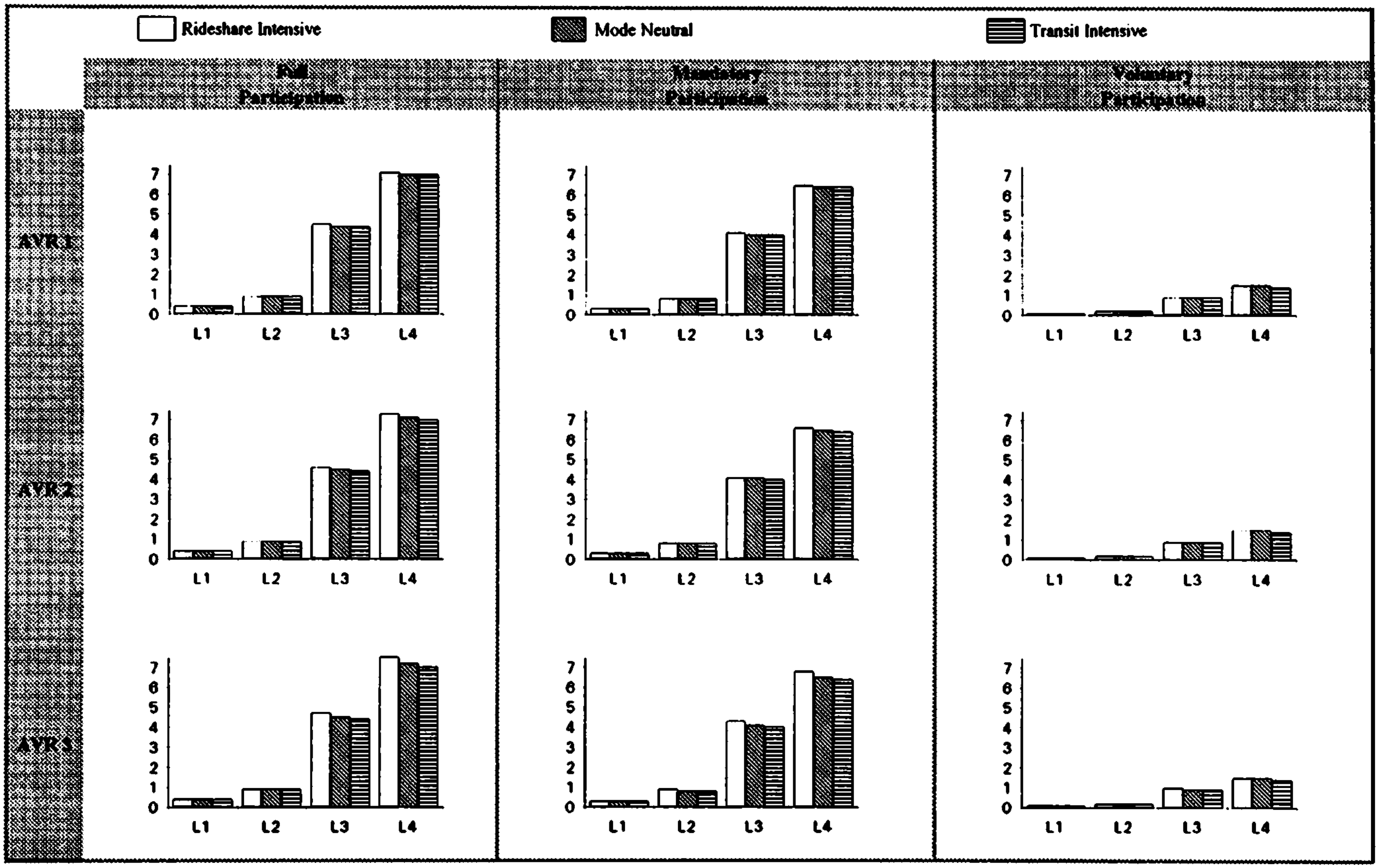


Table 3.3-3
Employer Support of Vanpooling

Table Represents Percent Vehicle Trip Reduction

AVR Setting	*Starting Mode Shares*					*Maximum Participation*				*Mandatory Participation*				*Voluntary Participation*			
						Level of Support				*Level of Support*				*Level of Support*			
	AVR	***DA***	***TR***	***CP***	***VP***	***1***	***2***	***3***	***4***	***1***	***2***	***3***	***4***	***1***	***2***	***3***	***4***
AVR1 CP	1.13	79.5	0.5	18.3	1.7	0.4	0.9	4.5	7.1	0.3	0.8	4.1	6.5	0.1	0.2	0.9	1.5
AVR1 EV	1.13	85.0	7.0	7.3	0.7	0.4	0.9	4.4	7.0	0.3	0.8	4.0	6.4	0.1	0.2	0.9	1.5
AVR1 TR	1.13	86.6	9.0	4.1	0.3	0.4	0.9	4.4	7.0	0.3	0.8	4.0	6.4	0.1	0.2	0.9	1.4
AVR2 CP	1.35	60.2	5.0	31.2	3.6	0.4	0.9	4.6	7.3	0.3	0.8	4.1	6.6	0.1	0.2	0.9	1.5
AVR2 EV	1.35	66.2	16.0	16.1	1.7	0.4	0.9	4.5	7.1	0.3	0.8	4.1	6.5	0.1	0.2	0.9	1.5
AVR2 TR	1.35	73.7	25.0	1.1	0.2	0.4	0.9	4.4	7.0	0.3	0.8	4.0	6.4	0.1	0.2	0.9	1.4
AVR3 CP	1.90	30.7	10.0	53.1	6.2	0.4	0.9	4.7	7.5	0.3	0.9	4.3	6.8	0.1	0.2	1.0	1.5
AVR3 EV	1.90	41.3	30.0	25.8	2.9	0.4	0.9	4.5	7.2	0.3	0.8	4.1	6.5	0.1	0.2	0.9	1.5
AVR3 TR	1.90	50.8	45.0	3.8	0.4	0.4	0.9	4.4	7.0	0.3	0.8	4.0	6.4	0.1	0.2	0.9	1.4

percent to 6.8 percent for the high AVR group. Under a **voluntary** situation, the level of trip reduction would range from 0.1 percent to 1.5 percent for all of the AVR groups -- low, medium and high.

SUMMARY

The reader will note in review of these actions that employer support programs -- while an important starting point -- do not in and of themselves produce significant trip reductions. Carpooling and transit support programs are projected to produce no more than a 2 percent to 3 percent vehicle trip reduction if implemented under even Mandatory conditions, and less than 1 percent if under Voluntary conditions. This is in close agreement with what has been observed in Southern California under Regulation XV and in Seattle. Vanpooling is projected to produce larger trip reductions -- more than twice as large -- but the underlying assumptions also call for more significant employer financial involvement in those programs, so they are not entirely comparable.

To gain impact from TDM, then, it is necessary to resort to other measures as well as employer support. These are discussed in the following section.

3.3.2.2 Incentives and Disincentives

Incentives increase the attractiveness of those modes to which they are applied, because they change the economic balance to the decision makers. Disincentives, in contrast, lessen the attractiveness of a mode that we wish travelers to use less often. Either can work alone; combined they are even more effective.

There are two types of incentive/disincentive actions: those that affect travel time and those that affect travel cost. Measures in each category are discussed below.

TRAVEL TIME INCENTIVES

Transit Service Improvements

A fundamental way of making transit more attractive as an alternative is to reduce the travel time involved in a transit trip compared to existing conditions and compared to travel by SOV. Transit encounters some natural disadvantages in trying to compete with the SOV: it cannot provide as complete or convenient service as the SOV on a door-to-door basis; it must travel on a planned schedule rather than at the whim of the user; it must often deviate from a straight-line route and make stops to pick up passengers and serve other destinations; and if it is bus transit, it generally must operate on the same congested roadways as private vehicles, thereby decreasing that *it can go no faster than* the SOV.

Improving transit service, or reducing its time of travel for the user, therefore involves measures to overcome or reduce the impacts of these disadvantages. These include:

- *Direct Routing* to eliminate circuitous travel paths;

- *Broader Coverage* to reduce the impediments to accessing the service (bring it closer to home or destination);

- *More Frequent Service* to reduce the wait imposed by schedule on the user;

- *Travel on Exclusive Way* in order to give the traveler an en-route travel time advantage over mixed traffic.

Travelers are relatively unconcerned about the particular technical measures that planners can take to improve transit service; they are concerned mainly about the "bottom line". How much travel time will it save compared to my current situation, and in relation to traveling by SOV? The type of time savings that is realized also makes a difference. Studies show that travelers make an important distinction between time which is saved in reaching the transit service -- both walking and waiting -- when they must expend active effort and are exposed to "the elements," vs. that time which is "spent" once actually on-board the vehicle, when they are generally seated and comfortable. The former is referred to as Out-of-Vehicle Time, and the latter as In-Vehicle time. Studies generally show that travelers value the time Out-of-Vehicle more than twice as much as that spent In-Vehicle; hence, policies that direct effort to saving Out-of-Vehicle time are generally more effective on demand, although they may also be more expensive to accommodate.

Figures 3.3-4A and 3.3-4B, and Table 3.3-4, illustrate the likely effects on travel, measured in percent vehicle trip reduction, associated with different levels of In-Vehicle and Out-of-Vehicle time savings, respectively. Again, according to convention, trip reduction results are projected for three different AVR environments, and with three different modal balances for each (transit heavy, even, and rideshare heavy). *Note that the level of employer participation is not considered here, since these are measures that would be implemented through the public sector and would be available to all travelers (so "voluntary" and "mandatory" scenarios are not presented).*

Starting with the In-Vehicle Time (IVT) savings in Figure 3.3-4A, it is shown that even major improvements to transit service in a low AVR environment -- characterizing typical suburban areas -- do not produce sizeable impacts in travel. Effecting five-to-ten-minute reductions in IVT compared to existing service only reduces vehicle trips by 0.7 percent to 1.5 percent (somewhat more if pre-existing transit use is higher than normal, considerably less -- almost nothing -- if there is little pre-existing transit

Figure 3.3-4
Transit Service Improvements

Figure 3.3-4A
In-Vehicle Time Savings

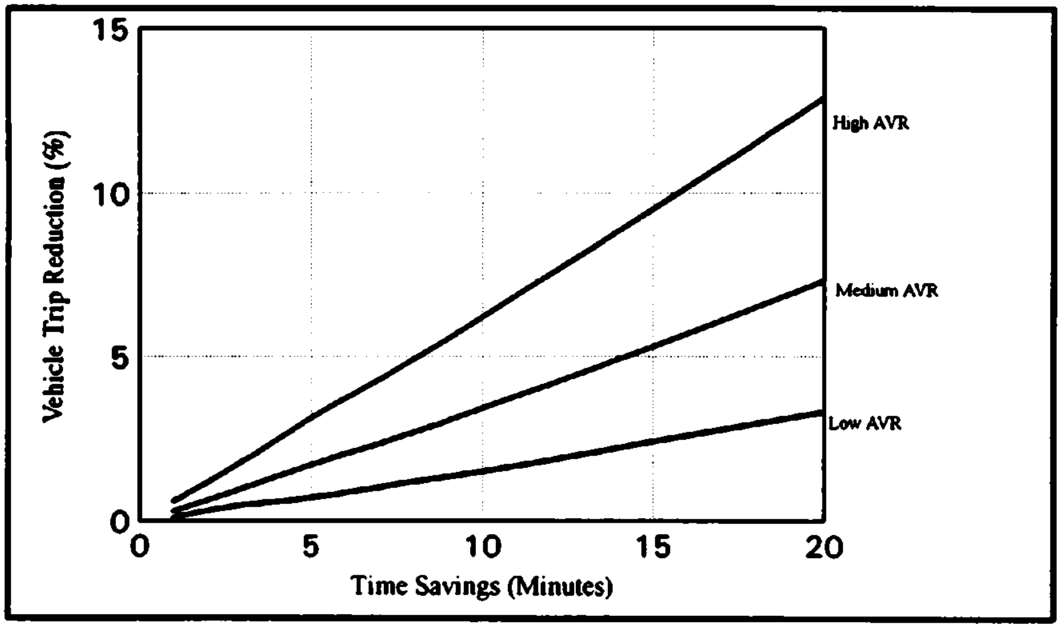


Figure 3.3-4B
Out of Vehicle Time Savings

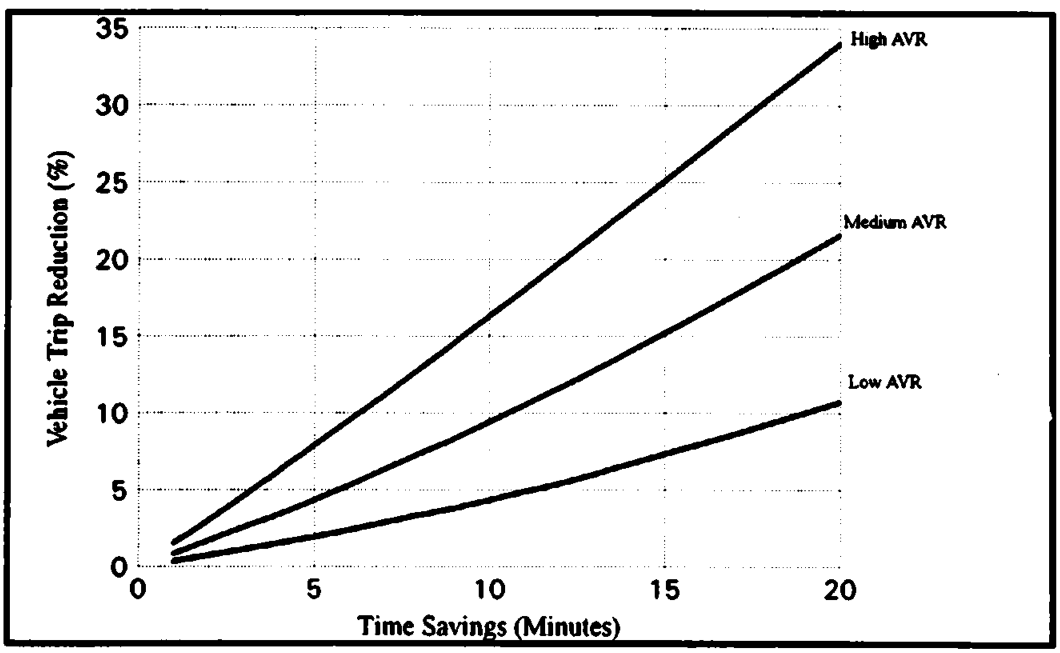


Table 3.3-4
Transit Service Improvements

In-Vehicle Time Savings

Table Shows Percent Vehicle Trip Reduction

AVR Setting	*Starting Mode Shares*					*Time Savings in Minutes*							
	AVR	*DA*	*TR*	*CP*	*VP*	*1*	*2.5*	*5*	*7.5*	*10*	*12*	*15*	*20*
AVR1 CP	1.13	79.5	0.5	18.3	1.7	0	0	0.1	0.1	0.1	0.1	0.2	0.2
AVR1 EV	1.13	85	7	7.3	0.7	0.1	0.4	0.7	1.1	1.5	1.9	2.4	3.3
AVR1 TR	1.13	86.6	9	4.1	0.3	0.2	0.5	0.9	1.4	2	2.5	3.1	4.2
AVR2 CP	1.35	60.2	5	31.2	3.6	0.1	0.3	0.5	0.8	1.1	1.4	1.7	2.4
AVR2 EV	1.35	66.2	16	16.1	1.7	0.3	0.8	1.7	2.5	3.4	4.3	5.3	7.3
AVR2 TR	1.35	73.7	25	1.1	0.2	0.5	1.3	2.6	3.9	5.2	6.6	8	10.9
AVR3 CP	1.9	30.7	10	53.1	6.2	0.2	0.5	1	1.6	2.2	2.8	3.4	4.7
AVR3 EV	1.9	41.3	30	25.8	2.9	0.6	1.5	3.1	4.6	6.2	7.9	9.5	12.9
AVR3 TR	1.9	50.8	45	3.8	0.4	0.9	2.3	4.5	6.8	9.1	11.3	13.6	18.1

Out-of-Vehicle Time Savings

Table Shows Percent Vehicle Trip Reduction

AVR Setting	*Starting Mode Shares*					*Time Savings in Minutes*							
	AVR	*DA*	*TR*	*CP*	*VP*	*1*	*2.5*	*5*	*7.5*	*10*	*12*	*15*	*20*
AVR1 CP	1.13	79.5	0.5	18.3	1.7	0	0.1	0.1	0.2	0.3	0.4	0.6	0.9
AVR1 EV	1.13	85	7	7.3	0.7	0.3	0.9	1.9	3.1	4.3	5.7	7.3	10.7
AVR1 TR	1.13	86.6	9	4.1	0.3	0.4	1.2	2.5	3.9	5.5	7.2	9.1	13.4
AVR2 CP	1.35	60.2	5	31.2	3.6	0.2	0.7	1.4	2.2	3.1	4.2	5.3	7.9
AVR2 EV	1.35	66.2	16	16.1	1.7	0.8	2.1	4.3	6.8	9.4	12.2	15.2	21.6
AVR2 TR	1.35	73.7	25	1.1	0.2	1.2	3.2	6.6	10.2	14	17.8	21.8	30
AVR3 CP	1.9	30.7	10	53.1	6.2	0.5	1.3	2.8	4.4	6.1	8	10	14.7
AVR3 EV	1.9	41.3	30	25.8	2.9	1.5	3.8	7.9	12	16.3	20.7	25.1	34
AVR3 TR	1.9	50.8	45	3.8	0.4	2.2	5.7	11.3	17	22.6	28.1	33.5	43.6

use). IVT *improvements of 20 minutes would produce only a 3.3 percent trip reduction, and would constitute an enormous amount of new service.*

In the higher AVR environments, the service improvements make a higher proportionate difference. In the medium AVR situation, 5 to 10 minute improvements in IVT could produce 1.7 percent to 3.4 percent trip reductions (extremes range from 0.5 percent to 5.2 percent, depending on modal balance), and in the high AVR situation, a reduction of 3.1 percent to 6.2 percent (extremes from 1.0 percent to 9.1 percent).

In contrast to the In-Vehicle improvements, the Out-of-Vehicle (OVT) improvements shown in Figure 3.3-4B show substantially greater returns. Effecting 5 to 10 minute reductions in OVT produces a 1.9 percent to 4.3 percent reduction in the low AVR case, 4.3 percent to 9.4 percent reduction in the medium AVR case, and a 7.9 percent to 16.3 percent reduction in the high AVR case.

What may be concluded from this analysis is:

- Transit service improvements that reduce Out-of-Vehicle travel time are clearly much more effective in attracting ridership than In-Vehicle improvements.
- Transit improvements of either type -- OVT or IVT -- are not terribly effective in suburban areas, defined as those locations where Average Vehicle Ridership is 1.20 or less. It would take substantial service offerings to begin to compete with the private SOV, the difficulty of providing which is compounded by the sprawled, low-density nature of the suburban environment.
- Transit is primarily an important strategy in activity centers, corridors and downtowns, (AVR of 1.21 and greater), and because of the cost of providing transit service, is best conceived as targeted service improvements to key, concentrated market segments.

<u>HOV Priority Lanes</u>

A popular way to provide en-route time savings that will benefit users of both transit and rideshare modes is through Preferential High-Occupancy Vehicle (HOV) Lanes. The idea here is to provide priority use of the transportation network to those travelers who use high-occupancy modes, and thereby save them travel time in relation to the SOV users. This time savings can result from the classic example of an HOV reserved lane on a radial expressway, to a more contemporary notion of savings from a network of reserved and diamond lanes throughout the travel system, as well as priority treatment at ramps and interchanges, all of which convey in-vehicle time savings.

The following issues are important in quantifying the benefit received from HOV facilities and projecting the travel response:

- How much time is saved in comparison to the usual trip?

- To whom is the savings provided (where the options are all transit and vanpool/carpool users with at least two occupants, to only vehicles with at least four occupants, to only transit vehicles)?

Figure 3.3-5 and Table 3.3-5 show estimated results of HOV treatments that provide savings to three different groups of users:

- All transit users and pools of 4 or more;

- All transit users and pools of 3 or more; and

- All transit users and pools of 2 or more.

As with the analysis of transit improvements, the impact of these savings is measured in terms of vehicle trip reduction as would occur in three different AVR environments -- low, medium and high. Also, three different modal balances are investigated for each AVR level. And, as with transit, because these services and benefits are engineered by the public sector, employer participation is not at issue, so regulatory requirements are not considered.

The first thing one notices in reviewing the different conditions represented in Figure 3.3-5 is that the HOV lane actions produce very different results depending on what level of occupancy restriction is applied (minimum number of people to be considered an eligible HOV) and the particular AVR environment. Broadly generalizing, what happens is:

- In a low or medium AVR environment, the greatest reductions in vehicle trips occur when the occupancy restriction level is kept at the minimum, i.e., HOV 2 or greater. Setting the restriction higher results in fewer people using the lane, and less impact, as well as the politically undesirable situation that the lane will appear underutilized and will come under attack by SOV users.

- In high AVR environments, where there is already an appreciable level of transit use, setting the occupancy restriction at a higher level (HOV 3+ or HOV 4+) results in greater utilization, and the greatest vehicle trip reductions.

Figure 3.3-5A
HOV Restriction at 2+

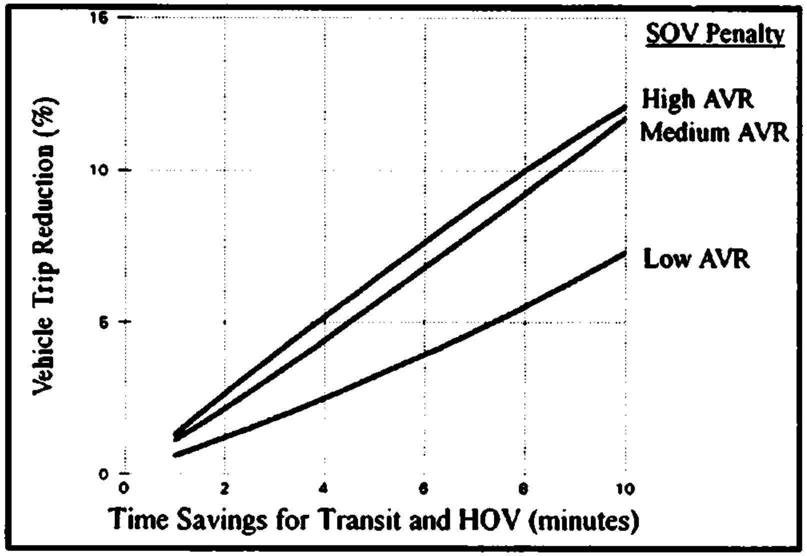


Figure 3.3-5B
HOV Restriction at 3+

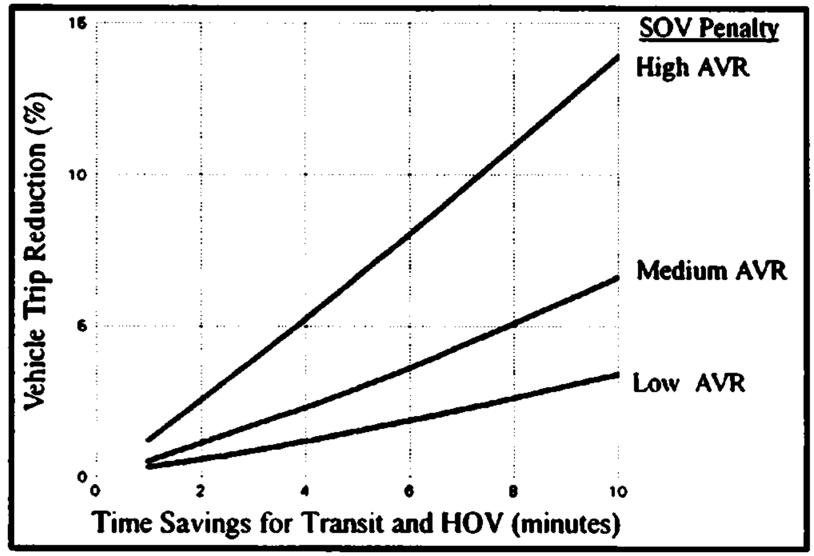


Figure 3.3-5C
HOV Restriction at 4+

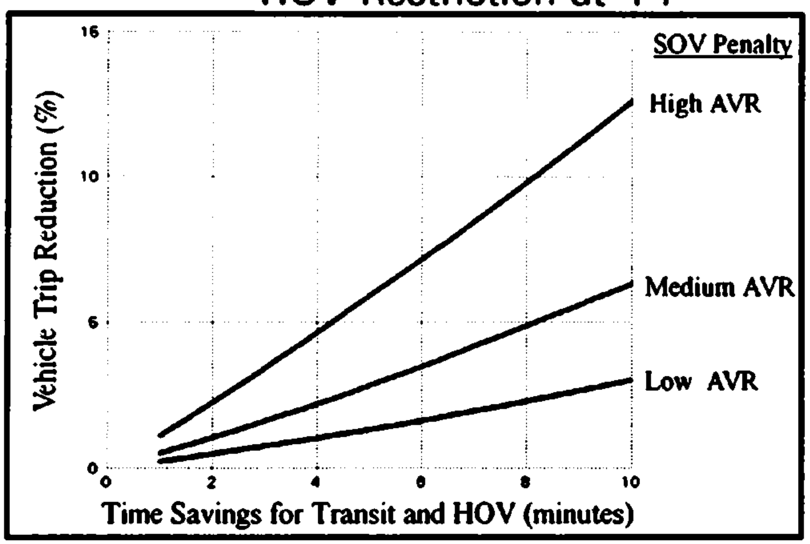


Figure 3.3-5
High Occupancy Vehicle Lanes

Table 3.3-5
High Occupancy Vehicle (HOV) Lanes

Tables Shows Percent Vehicle Trip Reduction

AVR Setting	*Time Savings (HOV 2+ & Transit) in Min.* 1	2.5	5	7.5	10
AVR1 CP	1.0	2.7	5.7	9.0	12.5
AVR1 EV	0.6	1.5	3.2	5.1	7.3
AVR1 TR	0.4	1.1	2.3	3.7	5.3
AVR2 CP	1.7	4.4	8.9	13.4	17.6
AVR2 EV	1.1	2.7	5.6	8.6	11.7
AVR2 TR	0.6	1.5	3.0	4.6	6.3
AVR3 CP	1.9	4.7	9.0	12.7	15.8
AVR3 EV	1.3	3.3	6.4	9.4	12.1
AVR3 TR	1.0	2.4	4.9	7.3	9.6

AVR Setting	*Time Savings (HOV 3+ & Transit) in Min.* 1	2.5	5	7.5	10
AVR1 CP	0.2	0.6	1.5	2.5	3.7
AVR1 EV	0.3	0.7	1.5	2.4	3.4
AVR1 TR	0.3	0.7	1.4	2.3	3.2
AVR2 CP	1.0	2.6	5.6	9.0	12.8
AVR2 EV	0.5	1.4	2.9	4.7	6.6
AVR2 TR	0.6	1.4	2.9	4.5	6.1
AVR3 CP	1.8	4.7	9.6	14.7	19.6
AVR3 EV	1.2	3.2	6.6	10.2	13.9
AVR3 TR	1.0	2.4	4.9	7.4	9.9

AVR Setting	*Time Savings (HOV 4 + & Transit) in Min.* 1	2.5	5	7.5	10
AVR1 CP	0.2	0.6	1.3	2.2	3.3
AVR1 EV	0.2	0.6	1.3	2.1	3.0
AVR1 TR	0.2	0.6	1.3	2.0	2.8
AVR2 CP	0.7	1.9	4.3	7.0	10.1
AVR2 EV	0.5	1.3	2.8	4.5	6.3
AVR2 TR	0.5	1.4	2.8	4.3	5.8
AVR3 CP	1.4	3.7	7.8	12.3	17.0
AVR3 EV	1.1	2.8	5.9	9.1	12.6
AVR3 TR	1.0	2.4	4.8	7.3	9.8

The reader will generally note that provision of time savings to all high-occupancy vehicle travelers -- i.e., not just transit users, but carpools and vanpools as well -- produces a greater impact on vehicle trip reduction than was observed with transit service improvements. Moreover, it is possible to provide these time savings at a much lower cost than would generally occur in supplying greater transit service, because most of the travelers are using their own vehicles. The trip reduction that results from a 5 to 10 minute savings from HOV lanes is 3.2 percent to 5.1 percent for HOV2/AVR1, compared to 0.7 percent to 1.5 percent for the same level of transit improvements.

Preferential Parking for HOVs

Another way of granting time savings to users of high-occupancy modes is to provide special parking privileges at the work site. What are being referred to here are time savings associated with affording users of multi-occupant vehicles close-in, reserved parking spaces, such that the search for a space is predictable and short, and the walk from the space to the office is as short as possible. Generally, the action is teamed with the opposite condition offered to SOV users -- unreserved (first-come/first-served) space availability, and locations either off site or in the more remote reaches of the parking facility.

Technically, this time savings should be of high value to potential ridesharers, since it involves out-of-vehicle time expenditure and also affects the predictability/reliability of the trip. *In practice, however, many employers offer such a limited version of this benefit, that there is no tangible time savings over SOV parking, hence it has little or no effect on mode choice.*

Figure 3.3-6 illustrates what this benefit could mean to potential rideshare users if particular levels of time savings were offered. This time savings must be visualized in terms of its component relationships, HOV time savings and SOV time penalties. Figure 3.3-6A illustrates the potential trip reduction effect if preferential parking savings were realized in a low AVR environment, while 3.3-6B and 3.3-6C reflect results under the medium and high AVR environments, respectively. In each of these cases, it is assumed that employers are implementing these actions. To eliminate some of the complexity of profiling multiple conditions, the graph profiles only the condition where employer participation is at a Maximum Level, i.e., 100 percent employer participation. Table 3.3-6 shows the lower trip reductions that would occur if participation were under Mandatory or Voluntary conditions. Analysis has not been done to show what would happen if the modal balance under the different AVR situations were tilted toward rideshare or transit use. Understand that the trip reductions presented here would be greater with an initial balance tilted toward ridesharing, and lesser if toward transit.

Figure 3.3-6A Low AVR

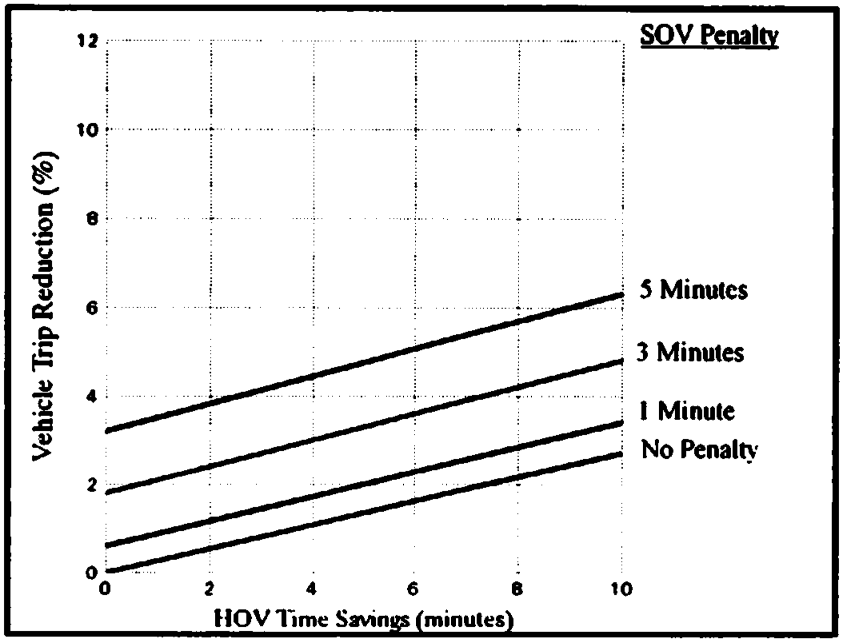


Figure 3.3-6B Medium AVR

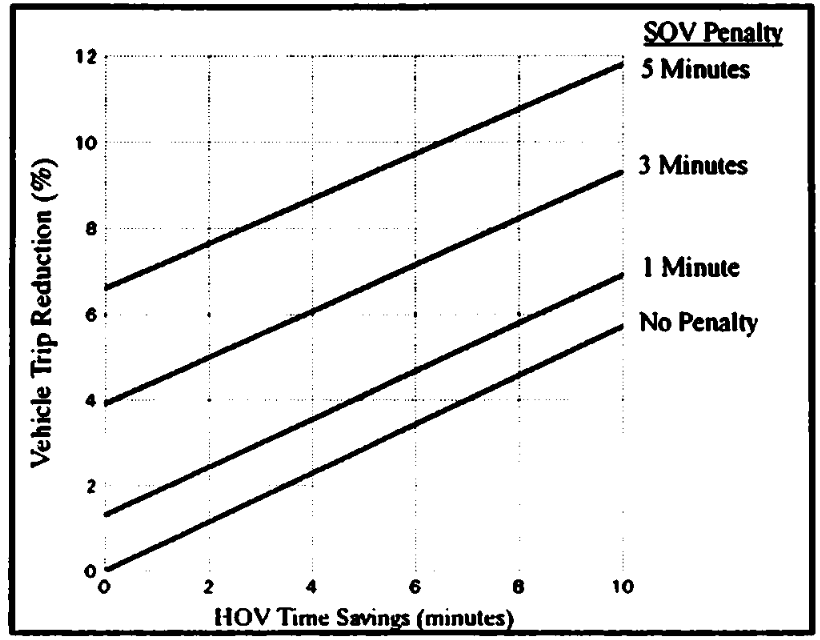


Figure 3.3-6C High AVR

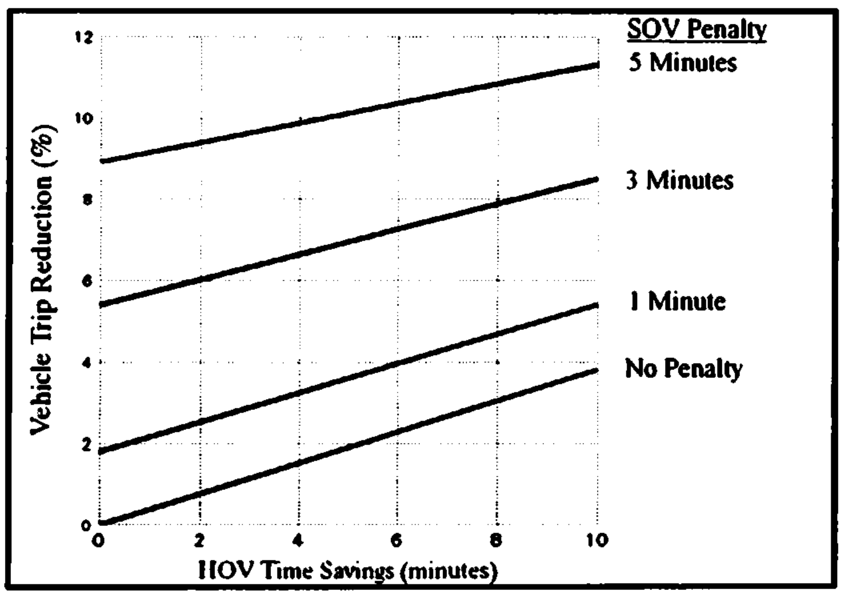


Figure 3.3-6
Preferential Parking for HOVs (Carpool & Vanpool) Maximum Participation Only

Table 3.3-6
Preferential Parking for High Occupancy Vehicles (HOVs)

Table Shows Percent Vehicle Trip Reduction

*Partici-pation**	*AVR Setting*	*SOV Penalty = 0 minutes*				
		HOV Time Savings (minutes)				
		0	*1*	*3*	*5*	*10*
	AVR1 EV	0.0	0.2	0.7	1.3	2.7
MAX	*AVR2 EV*	0.0	0.6	1.6	2.6	5.7
	AVR3 EV	0.0	0.4	1.0	1.8	3.8
	AVR1 EV	0.0	0.2	0.7	1.1	2.5
MAN	*AVR2 EV*	0.0	0.4	1.5	2.5	5.1
	AVR3 EV	0.0	0.4	0.0	1.6	3.4
	AVR1 EV	0.0	0.0	0.0	0.0	0.1
VOL	*AVR2 EV*	0.0	0.0	0.0	0.1	0.3
	AVR3 EV	0.0	0.0	0.0	0.0	0.2

*Partici-pation**	*AVR Setting*	*SOV Penalty = 1 minutes*				
		HOV Time Savings (minutes)				
		0	*1*	*3*	*5*	*10*
	AVR1 EV	0.6	0.8	1.4	1.9	3.4
MAX	*AVR2 EV*	1.3	1.9	2.9	3.9	6.9
	AVR3 EV	1.8	2.2	2.8	3.6	5.4
	AVR1 EV	0.6	0.8	1.3	1.7	3.1
MAN	*AVR2 EV*	1.2	1.6	2.6	3.6	6.3
	AVR3 EV	1.6	2.0	2.6	3.2	4.8
	AVR1 EV	0.0	0.0	0.0	0.1	0.1
VOL	*AVR2 EV*	0.0	0.1	0.1	0.1	0.3
	AVR3 EV	0.0	0.0	0.2	0.2	0.2

*Partici-pation**	*AVR Setting*	*SOV Penalty = 3 minutes*				
		HOV Time Savings (minutes)				
		0	*1*	*3*	*5*	*10*
	AVR1 EV	1.8	2.0	2.6	3.2	4.8
MAX	*AVR2 EV*	3.9	4.5	5.5	6.6	9.3
	AVR3 EV	5.4	5.6	6.2	6.8	8.5
	AVR1 EV	1.7	1.9	2.4	2.8	4.4
MAN	*AVR2 EV*	3.6	4.1	5.0	6.0	8.5
	AVR3 EV	5.0	5.2	5.6	6.2	7.6
	AVR1 EV	0.1	0.1	0.1	0.1	0.2
VOL	*AVR2 EV*	0.1	0.1	0.3	0.3	0.4
	AVR3 EV	0.2	0.2	0.2	0.2	0.4

*Partici-pation**	*AVR Setting*	*SOV Penalty = 5 minutes*				
		HOV Time Savings (minutes)				
		0	*1*	*3*	*5*	*10*
	AVR1 EV	3.2	3.4	4.0	4.6	6.3
MAX	AVR2 EV	6.6	7.1	8.2	9.2	11.8
	AVR3 EV	8.9	9.3	9.7	10.1	11.3
	AVR1 EV	2.8	3.1	3.6	4.5	5.7
MAN	AVR2 EV	6.0	6.4	7.3	8.3	10.8
	AVR3 EV	8.0	8.2	8.7	9.3	10.3
	AVR1 EV	0.1	0.1	0.1	0.2	0.2
VOL	AVR2 EV	0.3	0.3	0.3	0.4	0.4
	AVR3 EV	0.4	0.4	0.4	0.4	0.4

*Levels of Participation

MAX = Maximum
MAN = Mandatory
VOL = Voluntary

The reader will note that the greatest returns to preferential parking actions occur in the medium AVR environment, while the lowest impacts occur in the low AVR environment. The reason why the high AVR environment does not yield the greatest impacts is that transit share is highest in this AVR setting, and HOV preferential parking is beginning to divert transit users away to carpool and vanpool use (at lower occupancies).

How effective can preferential parking be? All depends on the level of time savings and the setting. In the low AVR setting, a 3-minute HOV time savings would yield only a 0.7 percent trip reduction; this would increase to 1.4 percent if an SOV penalty of 1-minute were also incorporated, and to 2.6 percent if a 3-minute SOV penalty were applied. The same conditions in the medium AVR environment would result in 1.6 percent, 2.9 percent and 5.5 percent reductions, respectively, and in the high AVR environment would result in 1.0 percent, 2.8 percent and 6.2 percent reductions, respectively. As can be seen, these are not large trip reductions, in and of themselves, but may be an effective component of a larger, more comprehensive TDM program.

Larger trip reductions can be had if it were possible to effect a larger differential through preferential parking, i.e., where the time savings differential were 10 minutes or greater. These types of savings could only be obtained if the employer were to use on-site/off-site parking rules, such as firms like Travelers Insurance in Hartford, where HOVs are given on-site spaces and SOVs are required to park off-site.

TRAVEL COST INCENTIVES

There are a number of ways by which the cost of travel can be modified to favor use of alternative modes. Subsidies can be granted to users of high-occupancy modes, or surcharges can be placed on users of SOVs. Obviously, combinations of these actions produce the greatest effectiveness, and have the additional benefit of creating the revenue source to support whatever subsidies may be paid out.

Exactly *how* the system of incentives or disincentives is related to the traveler is less important in the final analysis than the *net financial impact* that is experienced. Obviously, though, incentives are going to be more acceptable to travelers than disincentives, and hence will be easier to implement; on the other hand, the incentives, unless covered by some counterbalancing revenue source, are going to impose a cost burden on those who implement them. But these are operational and policy questions that are best addressed once the primary questions of impact potential are addressed. And as will be seen, these cost measures have the greatest impact potential of any TDM strategy.

Cost measures can be implemented by a government/public agency at an area-wide level, in the form of facility pricing, parking taxes or surcharges, or general levies, such as fuel or excise taxes. Public agencies have also been known to provide subsidies, either directly (Montgomery County, Maryland Fare Share Program) or through tax incentives (State of Delaware transportation management program). Alternatively, employers can be used as the implementing agent, through either charging for parking or providing subsidies, whereby the legal/regulatory directions governing their participation become important. There also exist Federal tax guidelines that substantially impact employers' dispositions toward pricing actions: providing subsidized parking for employees is an allowable business expense, whereas granting subsidies to users of alternative modes is treated as income to recipients. At the time of writing of this report, the IRS guidelines had been revised under the Federal Energy Bill to allow employers to subsidize transit and vanpool users up to $60 per month, in contrasts to a previous cap of $21 per month for transit users only. Carpooler subsidies are still taxable in any amount.

In light of all these issues, this presentation makes its focus projecting the **impact** that would be realized if pricing actions were imposed -- either through incentives or disincentives -- and leaves open for interpretation exactly **who would implement** those actions, or through **what specific instruments.**

Transit Subsidies

Figure 3.3-7A and Table 3.3-7 illustrate the trip reduction potential associated with progressive subsidies to transit users, ranging from $.50 per day to $4 per day, for each of the three AVR environments. In the low AVR setting, the model projects a range of vehicle trip reduction from 1.5 percent at $.50 per day to 21.7 percent at $4 per day in the low AVR setting. This impact is higher, 7.3 percent to 38.7 percent in the medium AVR setting, and from 6.2 percent to 54.3 percent in the high AVR setting where transit use is starting from a larger base. *It should be noted that the impacts indicated for the low AVR case at the higher subsidy levels [$2 to $4] are much higher than one might surmise from intuition; the reasons for this are (1) that the starting transit mode share for this analysis was 7 percent, which is high for a suburban AVR environment, and (2) subsidies at this level, especially at the $4 level, are well beyond what is done in conventional practice. It is suggested, therefore, that the reader also refer to Table 3.3-7, and review the impacts associated with the AVR1CP case, where transit use is at a more typical 0.5 percent, and the impacts are proportionately smaller.*

At a transit subsidy level of $1 per day, trip reductions of 3.3 percent would be realized in the low AVR environment, 7.3 percent in the medium AVR environment, and 12.9 percent in the high AVR environment. *Note that this assumes offering of the subsidy to all eligible travelers, so that if employers were the agent for the subsidy, employer participation at anything under Maximum level (100 percent) would reduce these impacts.*

HOV Subsidies

Figure 3.3-7B and Table 3.3-7 show the trip reduction potential that would result from providing the same type of subsidy levels described above to all HOV users, defined as all vanpoolers and members of carpools of two or more.

Figure 3.3-7B indicates that, in the low AVR setting, HOV subsidies seem to have about the same impact potential as do transit subsidies, and progressively less impact in the medium and high AVR settings where transit is in greater existing use. In the low AVR setting, HOV subsidies produce trip reductions of 2.5 percent for a $1 daily subsidy to 17.0 percent for a $4 daily subsidy. In the medium AVR setting, HOV subsidies yield net trip reductions of 4.1 percent to 21.3 percent for $1 and $4 daily subsidies, while in the high AVR setting, HOV subsidies of $1 and $4 produce trip reductions of 3.9 percent to 15.9 percent, respectively. The decline in effectiveness in the high AVR setting occurs because, should subsidies be offered only to HOV users, the incentive will begin pulling travelers from transit and placing them in lower occupancy situations at a rate that will diminish trip reduction.

The guidance taken from these simple curves in Figure 3.3-7B requires more interpretation and insight in order to be correct, however. The effectiveness of any subsidy -- HOV or Transit -- depends greatly on the setting, in terms of the availability of these alternatives and their pre-existing balances. For environments where the predominant alternative to the SOV is ridesharing (carpool or vanpool), offering subsidies to HOV users will result in much greater dividends than will transit subsidies. Conversely, in markets where transit is a viable alternative, then subsidies to encourage greater transit use will be more effective on the bottom line. This effect is not illustrated as well in the Figure 3.3-7A and B portrayal as it is in the Table 3.3-7 data, and is worth a separate discussion.

Figure 3.3-7B suggests that application of the same level of per capita subsidy to HOV users will yield a lower trip reduction than an equivalent subsidy to transit users. While these projections are accurate relative to the starting data assumptions on mode shares, they assume a starting situation where transit and HOV shares are about equal. To profile such an environment means setting transit share at levels that are unusually high in typical low and medium AVR settings, where transit and rideshare use are not at an even level, but ridesharing is generally dominant. If this fact is introduced to the analysis, and ridesharing is profiled as the dominant alternative to SOV, the results and recommendations are quite different than what is implied in Figure 3.3-7B.

If an entity were to provide subsidies to transit users only in low and medium AVR settings (where ridesharing is the dominant existing alternative), it would in generally produce very modest effects on transit use and trip reduction, where -- in contrast --

Figure 3.3-7A
Transit Subsidies

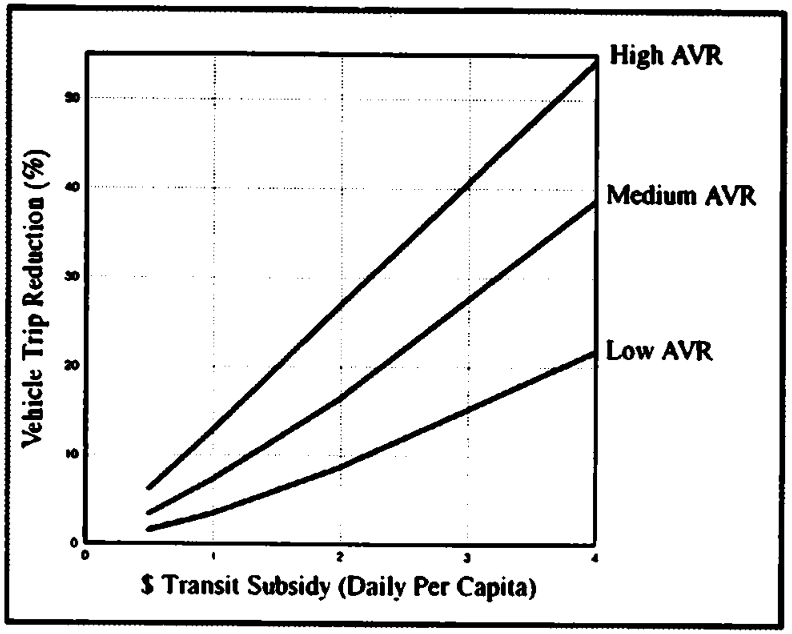


Figure 3.3-7B
HOV Subsidies

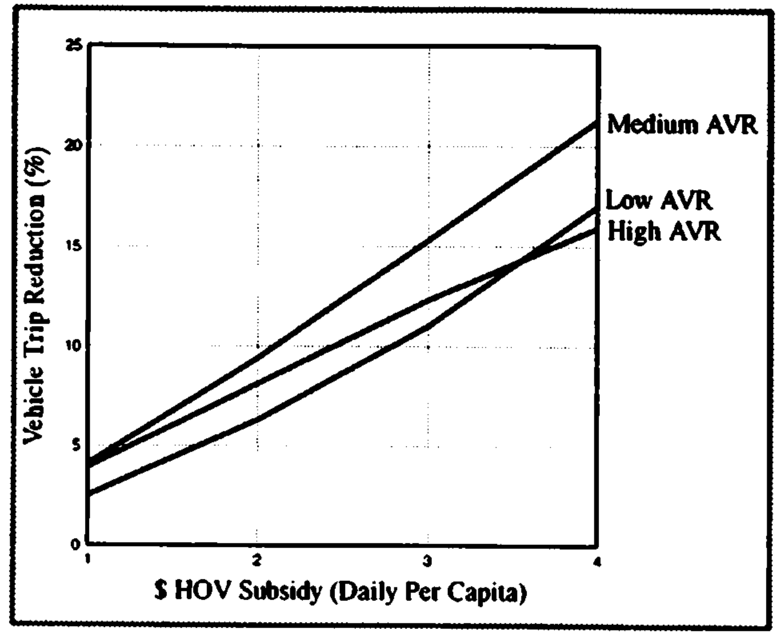


Figure 3.3-7C
SOV Surcharges

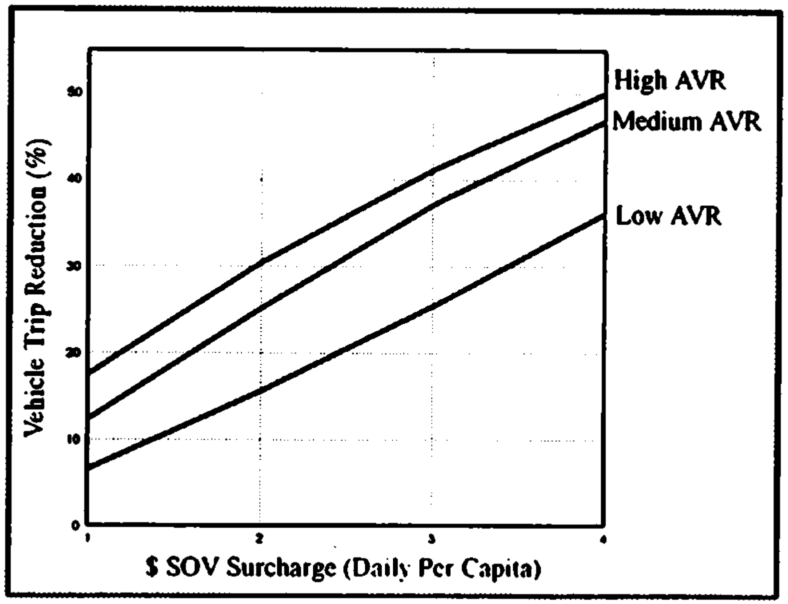


Figure 3.3-7
HOV Subsidies And SOV Surcharges

Table 3.3-7
Effects of Subsidies and Surcharges

Table Shows Percent Vehicle Trip Reduction

AVR Setting	*Daily Transit Subsidy* $0.50	$1	$2	$4
AVR1 CP	0.1	0.2	0.6	1.9
AVR1 EV	1.5	3.3	7.9	21.7
AVR1 TR	2.0	4.2	9.9	23.2
AVR2 CP	1.1	2.4	5.8	16.5
AVR2 EV	3.4	7.3	16.4	38.7
AVR2 TR	5.2	10.9	23.5	49.7
AVR3 CP	2.2	4.7	10.9	28.3
AVR3 EV	6.2	12.9	26.9	54.3
AVR3 TR	9.1	18.1	35.5	64.0

AVR Setting	*Daily HOV* Per Capita Subsidy* $1	$2	$3	$4
AVR1 CP	5.6	12.6	20.2	27.6
AVR1 EV	2.5	6.1	11.0	17.0
AVR1 TR	1.4	3.6	6.8	11.1
AVR2 CP	8.4	17.0	24.9	31.4
AVR2 EV	4.1	9.4	15.3	21.3
AVR2 TR	0.5	1.2	2.4	4.3
AVR3 CP	8.1	14.7	19.6	23.0
AVR3 EV	3.9	8.1	2.3	15.9
AVR3 TR	0.5	1.2	2.3	3.8

AVR Setting	*Daily SOV Surcharge* $1	$2	$3	$4
AVR1 CP	5.9	13.1	21.0	28.6
AVR1 EV	6.5	15.1	25.3	36.1
AVR1 TR	6.7	15.7	26.7	38.8
AVR2 CP	10.8	21.4	30.7	37.9
AVR2 EV	12.3	25.1	37.0	46.8
AVR2 TR	14.3	30.5	46.8	61.4
AVR3 CP	12.4	21.7	28.2	32.5
AVR3 EV	17.5	31.8	42.6	50.0
AVR3 TR	22.5	42.6	58.7	70.6

* Carpool / Vanpool only

offering the same subsidy for ridesharing would be extremely effective. To confirm this, examine the impacts cited in Table 3.3-7 for transit subsidies and for HOV subsidies in the following categories:

Low AVR	EVEN BALANCE (AVR1EV), $2 SUBSIDY	
	If subsidy to transit, Trip Reduction	= 7.9%
	If subsidy to HOV, Trip Reduction	= 6.1%
	RIDESHARE HEAVY (AVR1CP)), $2 SUBSIDY:	
	If subsidy to transit, Trip Reduction	= 0.6%
	If subsidy to HOV, Trip Reduction	= 12.6%
Medium AVR	EVEN BALANCE (AVR2EV), $2 SUBSIDY:	
	If subsidy to transit, Trip Reduction	= 16.4%
	If subsidy to HOV, Trip Reduction	= 15.3%
	RIDESHARE HEAVY (AVR2CP), $2 SUBSIDY:	
	If subsidy to transit, Trip Reduction	= 2.4%
	If subsidy to HOV, Trip Reduction	= 17.0%

Note from the above that gains to trip reduction are substantially greater in the low AVR case when HOVs are dominant (AVR1CP) and subsidies are focused on HOVs, and still somewhat greater in medium AVR environments when HOVs are the dominant alternative mode (AVR2CP). So clearly, much depends on the initial mode share assumption, and one must recognize that in most of our current high-traffic trouble spots (predominately low density areas), the greatest in-place resource and potential is with ridesharing, and not with transit.

Why is this so important to point out? Because without knowledge of these relationships, the tax subsidy guidelines, conventional wisdom and political pressure would direct most entities to concentrate subsidies on transit users. However, except for environments where transit is a viable alternative (i.e., mainly in high-density corridors and downtowns), providing subsidies to increase transit use will not be nearly as effective as HOV subsidies. Yet, in order to realize this impact potential through HOV subsidies, the major barriers of current tax law and conventional wisdom must be overcome through new implementation strategies. The best all-around strategy is probably to subsidize both modes, so that users can decide which option works best for them; again, the current tax laws and intuition do not allow for such flexibility.

SOV Surcharges

The *single most effective* instrument for diverting travelers away from the SOV is the surcharge, or "disincentive." Figure 3.3-7C and Table 3.3-7 illustrate the trip reduction associated with the application of progressive surcharges on SOV users. SOV surcharges produce a 6.5 percent to 36.1 percent trip reduction for $1 and $4 surcharges, respectively, in the low AVR environment; and an equivalent 12.3 percent to 46.8 percent reduction in the medium AVR setting, and 17.5 percent to 50 percent in the high AVR setting. Note that the effects increase progressively over the three AVR environments, from low to high. This is because travelers are *priced out of SOVs* rather than *drawn to a specific alternative mode*, which allows them to switch to the most appropriate mode.

SOV Surcharges Teamed with HOV and Transit Subsidies

The optimal application of pricing actions is to impose a disincentive on SOV use while at the same time offering an equal subsidy level to any alternative mode user. Figures 3.3-8 A, B and C offer an indication of what effects would be realized if the HOV/transit subsidies and SOV surcharges were imposed simultaneously -- in different combinations. Each graphic shows the resulting trip reduction impact in three different AVR environments. Table 3.3-8 provides detail of what happens when the starting modal balance favors transit or carpool in each AVR setting.

Note some interesting trends in these relationships across the three AVR settings:

> In the low AVR case (Figure 3.3-9A), progressive increases in subsidy and surcharge continue to produce increases in vehicle trip reduction, *except that at SOV surcharge levels of $3 or greater, continued application of subsidy and surcharge results in a diminishing return in trip reduction.* Ultimate trip reduction impact in the low AVR setting shown in this analysis is 60 percent, but is probably greater.
>
> In the medium AVR case, trip reduction benefits increase with each added application of subsidy/surcharge, *though at an increasingly declining rate as higher levels of subsidy/surcharge are applied. At the highest level of surcharge, $4, any increases in subsidy beyond $3 meet with no further gains in trip reduction.* Ultimate trip reduction impact for the medium AVR setting appears to be about 58 percent.
>
> In the high AVR case, all surcharge/subsidy applications result in an increase in trip reduction but at an ever-declining rate. *At the $3 and $4 levels of surcharge, increases in subsidy have little or no additional trip reduction impact.* Ultimate trip reduction impact for the high AVR setting appears to be about 54 percent.

Figure 3.3-8A
Low AVR

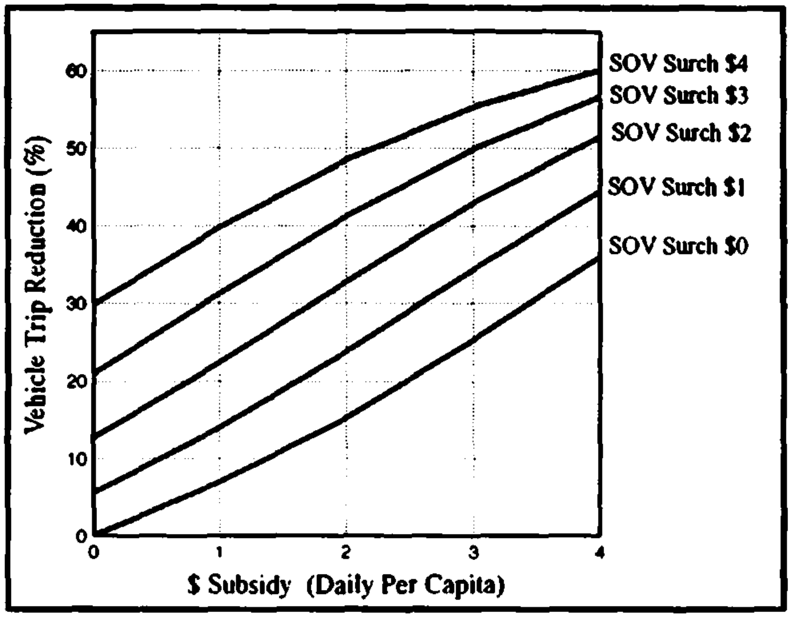


Figure 3.3-8B
Medium AVR

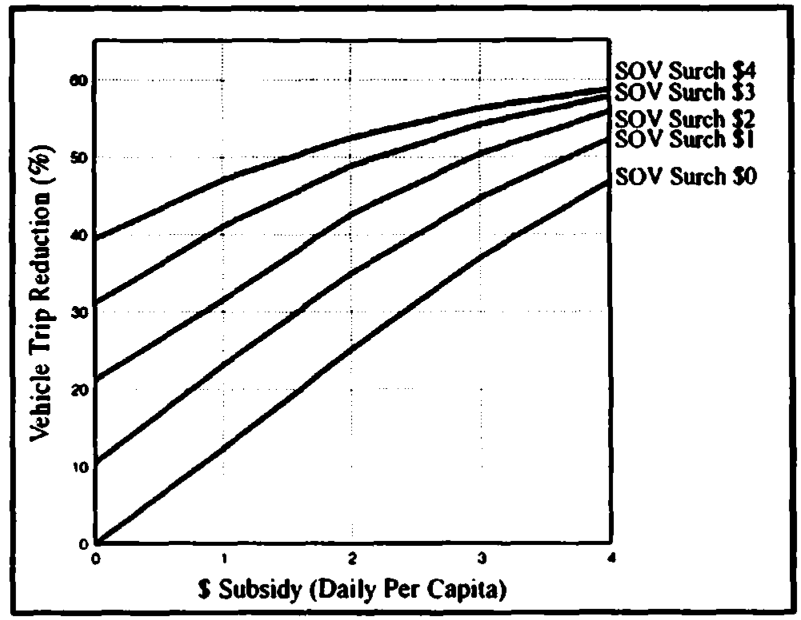


Figure 3.3-8C
High AVR

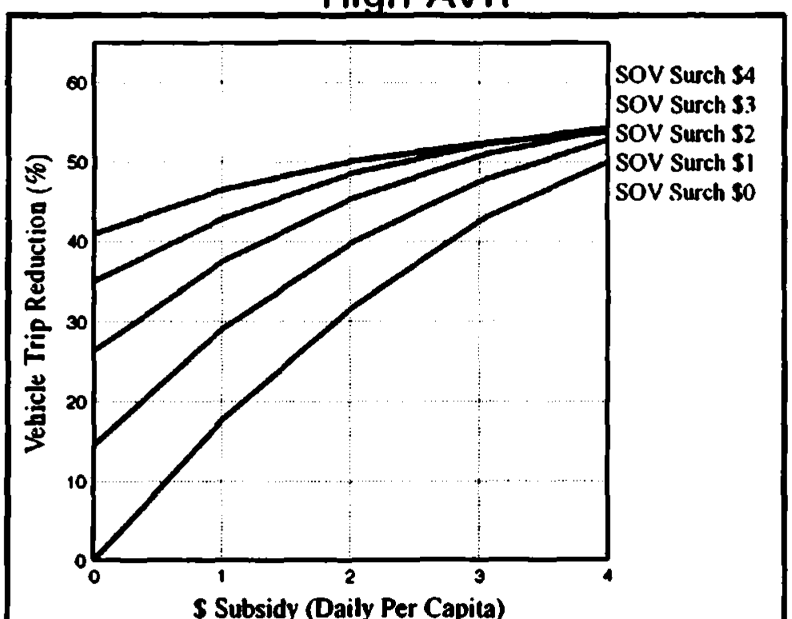


Figure 3.3-8
HOV/Transit Subsidies vs. SOV Surcharges

Table 3.3-8

HOV/Transit Subsidies and SOV Surcharges (Daily Per Capita)

Table Shows Percent Vehicle Trip Reduction

AVR Setting	HOV & Transit Subsidy = $0				
	SOV Surcharge				
	$0	$1	$2	$3	$4
AVR1 CP	0.0	5.9	13.1	21.0	28.6
AVR1 EV	0.0	6.5	15.1	25.3	36.1
AVR1 TR	0.0	6.7	15.7	26.7	38.8
AVR2 CP	0.0	10.8	21.4	30.7	37.9
AVR2 EV	0.0	12.3	25.1	37.0	46.8
AVR2 TR	0.0	14.3	30.5	46.8	61.4
AVR3 CP	0.0	12.4	21.7	28.2	32.5
AVR3 EV	0.0	17.5	31.8	42.6	50.0
AVR3 TR	0.0	22.5	42.6	58.7	70.6

AVR Setting	HOV & Transit Subsidy = $1				
	SOV Surcharge				
	$0	$1	$2	$3	$4
AVR1 CP	5.8	13.0	20.9	28.5	35.0
AVR1 EV	5.6	13.9	23.8	34.4	44.5
AVR1 TR	5.5	14.1	24.8	36.6	48.3
AVR2 CP	10.2	20.8	30.0	37.2	42.4
AVR2 EV	10.5	23.1	34.9	44.8	52.2
AVR2 TR	11.3	27.2	43.6	58.6	70.9
AVR3 CP	11.3	20.6	27.2	31.6	34.4
AVR3 EV	14.5	29.1	40.0	47.7	52.8
AVR3 TR	18.1	38.8	55.6	68.2	76.9

AVR Setting	HOV & Transit Subsidy = $2				
	SOV Surcharge				
	$0	$1	$2	$3	$4
AVR1 CP	13.0	20.8	28.4	34.9	40.0
AVR1 EV	12.7	22.4	32.8	42.9	51.5
AVR1 TR	12.6	22.9	34.5	46.1	56.5
AVR2 CP	20.1	29.3	36.6	41.8	45.4
AVR2 EV	21.2	33.0	42.9	50.4	55.8
AVR2 TR	24.0	40.5	55.8	68.6	78.3
AVR3 CP	19.6	26.2	30.6	33.5	35.3
AVR3 EV	26.3	37.5	45.4	50.7	54.1
AVR3 TR	34.8	52.3	65.6	74.9	81.1

AVR Setting	HOV & Transit Subsidy = $3				
	SOV Surcharge				
	$0	$1	$2	$3	$4
AVR1 CP	20.7	28.3	34.8	39.9	43.5
AVR1 EV	21.0	31.3	41.3	49.9	56.6
AVR1 TR	21.1	32.5	44.0	54.5	62.8
AVR2 CP	28.7	36.0	41.2	44.8	47.2
AVR2 EV	31.1	41.0	48.7	54.1	57.7
AVR2 TR	37.3	52.9	66.3	76.5	83.8
AVR3 CP	25.3	29.8	32.8	34.4	35.6
AVR3 EV	35.0	43.1	48.5	52.0	54.3
AVR3 TR	48.9	62.9	72.8	79.5	83.8

AVR Setting	HOV & Transit Subsidy = $4				
	SOV Surcharge				
	$0	$1	$2	$3	$4
AVR1 CP	28.2	34.7	39.8	43.4	45.8
AVR1 EV	29.9	39.8	48.4	55.2	60.0
AVR1 TR	30.5	42.0	52.5	61.0	67.4
AVR2 CP	35.4	40.7	44.3	46.6	48.1
AVR2 EV	39.3	47.0	52.5	56.2	58.6
AVR2 TR	50.0	63.8	74.6	82.4	87.7
AVR3 CP	29.0	31.8	33.7	34.8	35.5
AVR3 EV	40.9	46.4	50.0	52.3	53.7
AVR3 TR	60.0	70.5	77.7	82.3	85.3

These relationships make it very clear that one cannot simply add up effects of individual strategies to ascertain the effect of a TDM program. TDM strategies combine in very non-linear and unpredictable ways, depending on the setting and the interaction between strategies. For this reason, it is necessary to develop a TDM program using comprehensive assessment methods, such as are provided through the TDM model or the supplemental Guidance Manuals.

3.3.2.3 Alternative Work Schedules

Vehicle trips can also be reduced by altering the time or frequency with which a trip occurs. There are two primary ways in which this can occur:

Time Shifting: The trip is simply moved to another, less congested, time period. This is the nature of *flexible work hours* and *staggered work hour* arrangements.

Trip Elimination: The trip is physically not made some or all of the time. This is the object of *compressed work weeks* and *telecommute/work at home* policies.

It is important to recognize the difference in these two types of strategies. While time shifting can be effective in alleviating (or heading off) a concentrated congestion problem by simply pushing trips out of the peak, this approach generally does not contribute to net travel efficiency; in other words, the same number of vehicle trips is still made, only at a different time period. Whether such an approach to reducing vehicle traffic volumes is acceptable will depend on the particular motivation behind the program. If the motivation is based on reducing overall vehicle trips and vehicle miles of travel, as with air quality regulations, then this method may not be fully effective or acceptable.

Trip frequency measures, on the other hand, do have the effect of eliminating the actual trip and VMT, so they may be effective in achieving air quality-based as well as more conventional traffic alleviation goals. If questions do arise concerning net travel impacts with the trip frequency measures, they are regarding whether the traveler is able to fully dispense with travel if not commuting, or the quantity, type and location of travel that does occur on these non-commute travel days.

It is somewhat more difficult to project the effects of these alternative work schedule actions on travel behavior than it is with the modal choice alternatives discussed previously. Shifting of travel time or frequency is not a well-studied or documented subject in travel studies. Hence, there is considerable room for error in speculating what is achievable.

One of the most comprehensive databases on the subject is found in southern California, through the South Coast Air Quality Management District's Regulation XV Employer Trip Reduction Plan data. A review of the records of 3,953 employers who have been required by law to implement measures to reduce vehicle travel shows the following results in relation to Alternative Work Schedule measures:

Type Measure	Percent Employers Offering	Percent Employees Using	Percent Employees Using Where Not Offered by Employer
Telecommuting	1.3%	2.1%	0.3%
Compressed Weeks:			
4/40	5.8%	5.6%	0.8%
3/36	0.8%	2.6%	0.5%
9/80	2.7%	0.8%	0.2%

These numbers suggest a fairly modest impact from work hours measures, relative to what might be expected, particularly under a "mandatory" environment. Meanwhile, there are other examples, particularly in the outlying San Francisco Bay Area counties, where employers who have been required to meet a peak hour trip requirement have done so largely through alternative work schedules, with relatively little change in mode choice. A rough study of individual cases such as these has suggested that, if an employer offers an alternative work schedule arrangement to its employees, approximately 22 percent of those employees will opt to use that opportunity and change their travel schedule.

Given the scarcity and conflict in information, the TDM Evaluation Model incorporates a methodology that tempers the limited empirical knowledge on alternative work schedules with an ability to make reasoned assumptions in conducting an analysis of the potential contribution of these strategies. The methodology involves the following steps:

1. **Eligibility:** The user first indicates the percent of employees who would be offered the opportunity to engage in the particular action, e.g., the percentage of employees at a given employer (or within a given employment setting) who would be allowed to follow a 4/40 work week.

2. **Behavior Modification:** Given that an employee has a choice regarding an alternative work schedule option, only a percentage of those (generally 22 percent) would be expected to "modify their behavior" and utilize that option.

3. **Employer Participation:** The percentage of employers who would offer the measure in the first place is simulated by the employer participation rate, which

varies depending on whether the employer is acting in self-interest (voluntary), or under law (mandatory).

The actual percentage of trips reduced then is a product of the three factors considered above. In the following sections, the model has been used to project the effects of some popular work schedule measures, illustrating the interplay of these factors. The measures analyzed include:

- *Flexible Work Hours*
- *Staggered Work Hours*
- *4/40 Work Weeks*
- *9/80 Work Weeks*
- *Telecommuting*

Each of these is analyzed individually, keeping with the established format. Within the model, however, more than one strategy can be evaluated at one time as part of a realistic, multi-element program.

<u>Flexible Work Hours</u>

Under a Flexible Work Hours policy, an employer permits his employees to travel at a time that differs from the organization's official work hours. This is not to be construed as flexible schedules, which is where the employer allows employees who carpool or use transit some grace in order to accommodate schedule conflicts with their mode. Rather, this is generally a formal shift in the time that the employee arrives at/leaves the work site, specifically to travel off-peak.

In this, as well as each of the other alternative work schedule arrangements, it is assumed that the alternate schedule has no impact on overall mode split for the employer; in other words, it is assumed that if a given percentage of employees shift travel time, that the average modal split of those who change is the same as those who do not shift (and the same as the aggregate before the policy). It is difficult, from the available data, to say conclusively whether this assumption is valid or invalid. In some instances, data indicate that employees who travel outside the peak hour are more inclined to revert to SOV travel because it is most convenient. In other instances, data indicate the opposite, that a higher proportion of HOV users travel outside the peak. Because the empirical results are inconclusive, the model takes the conservative position that mode split is unaffected by time shifts.

Figure 3.3-9 illustrates the projected effect on vehicle trips of employer-based Flexible Work Hours measures. The curves indicate the percent trip reduction that would be realized under:

- Participation conditions ranging from Voluntary through Mandatory to Maximum (note that the model has been structured to reflect that this action will be primarily supported by Office [white collar and professional services] and not Non-Office [manufacturing and trade] employers).

- Increases in the number of employees who are eligible to participate in such a program, expressed in terms of Percent of Employees Eligible.

The analysis suggests that, under Voluntary participation conditions, if as many as 50 percent of employees are permitted to participate in such a program, an approximately 2 percent reduction in vehicle trips is produced. Under a mandatory condition, it is projected that the trip reduction could reach 8 percent, with the theoretical upper limit under Maximum participation as 9 percent. *Note that the trip reductions illustrated here involve merely a shifting of the trip to another time period, and not elimination of the trip.*

The reader will note that the graph suggests a straight line relationship. Thus, if more than 50 percent of employees were declared eligible, then the trip reduction would increase in proportion to the percent eligibility.

<u>Staggered Work Hours</u>

Figure 3.3-10 presents a similar analysis for the policy of Staggered Work Hours. With staggered work hours, the employer generally effects a formal change in work hours for the work force, such that:

- All employees are moved to a new set of work hours that fall outside the peak for the surrounding area; or

- More than one set of official work hours are established, and the work force is partitioned into groups that arrive/depart formally at these "staggered" times. The 3M Company, for example, splits its work force into two groups -- administrative and scientist -- which then arrive/depart on separate schedules. This method substantially alleviated 3M's traffic problems at their St. Paul site.

The analysis of staggered work hours with the TDM model is similar to the relationships for flexible work hours, except that it is assumed that non-office employers are likely to participate as well, and the rate of shift for these employees is set at 5 percent in comparison to 22 percent for the office employees. This

Figure 3.3-9
Flexible Work Hours

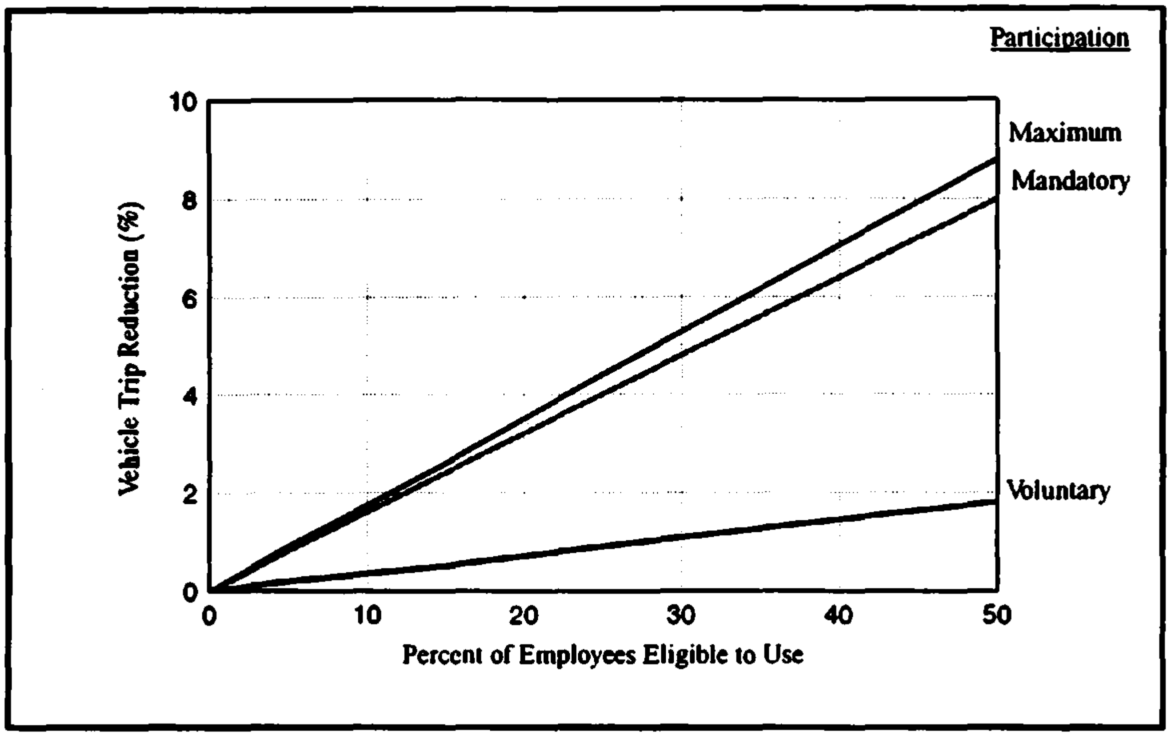
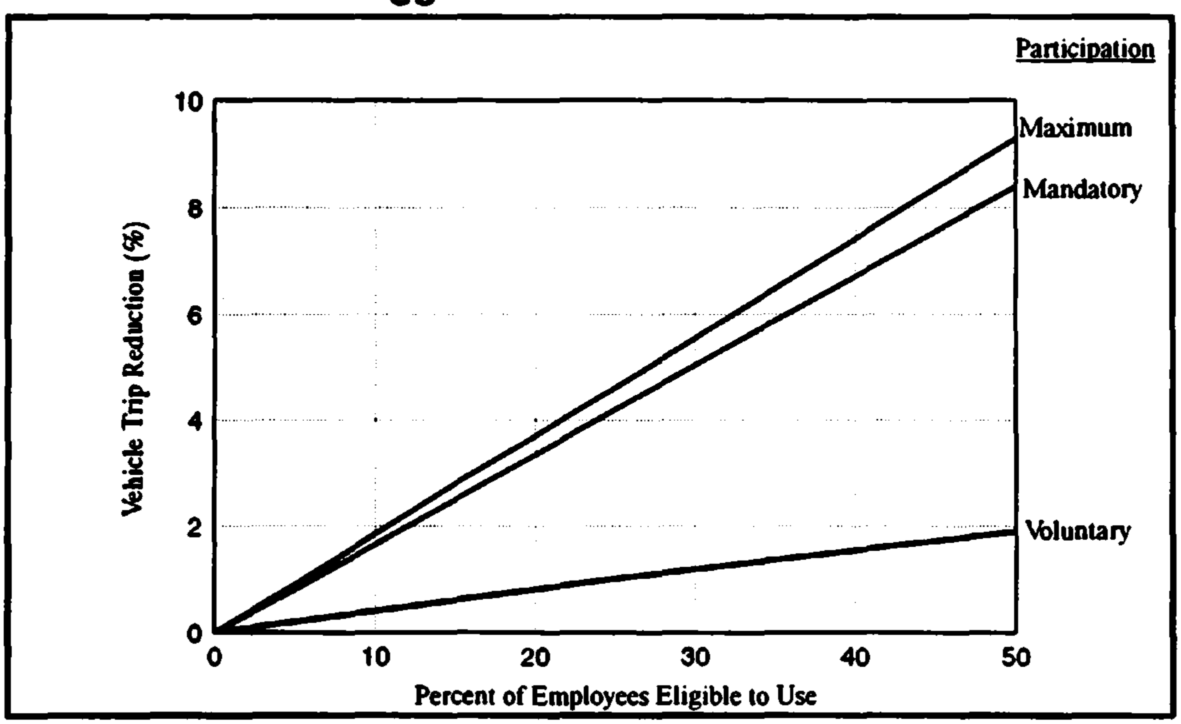


Figure 3.3-10
Staggered Work Hours



extension of the effect of the policy to non-office employers pushes the vehicle trip reduction impact up slightly beyond what was projected for flexible work hours. *Note again that the trip reductions illustrated here involve merely a shifting of the trip to another time period, and not elimination of the trip.*

Compressed Work Weeks

Figures 3.3-11A and B illustrates the trip reduction effects of Compressed Work Week policies. Under these arrangements, employees work a somewhat longer typical day, and in exchange, are given a day off on which they do not have to travel to the site. Under the 4/40 arrangement, shown in Figure 3.3-11A, the employee works four 10-hour days per week and receives the fifth day off. Under the 9/80 arrangement, shown in Figure 3.3-11B, there is a 9-hour work day over a two-week cycle, followed by a tenth day off.

These measures accomplish a dual effect on travel and traffic congestion. First, because each day is made longer, the trips to the site that do occur may be shifted in time outside the peak hours, and thereby have a short-term mitigating effect on traffic. Second, and perhaps most important, eliminating the need to travel to the site one day a week or every other week represents a 20 percent (for the 4/40) or 10 percent (for the 9/80) net reduction in vehicle travel for the participating employee.

The curves in Figure 3.3-11A indicate that, should as many as 50 percent of employees be eligible to participate in a 4/40 program, a trip reduction (actual elimination) of about 2 percent would occur under Voluntary participation conditions, and about 8 percent under Mandatory conditions. In the case of the 9/80 arrangement shown in Figure 3.3-11B, trip reductions would be exactly half that of the 4/40.

The model assumes that compressed work week arrangements will only be offered by Office employers, and not Non-Office, since for industrial, manufacturing and trade operations, it would appear unlikely that employees could be spared coming to an actual work site.

Telecommuting

The final time management strategy in this group is Telecommuting, a popular term given to the concept of working without reporting to a formal or central work site.

In most cases, this involves the employee working at home, and communicating with the central office site via telecommunications technology (computer, telephone, fax, etc.). This may be done occasionally, or on a virtually full-time basis for particular employees.

Figure 3.3-11 Compressed Work Weeks

Figure 3.3-11A
4-40 Compressed Work Week

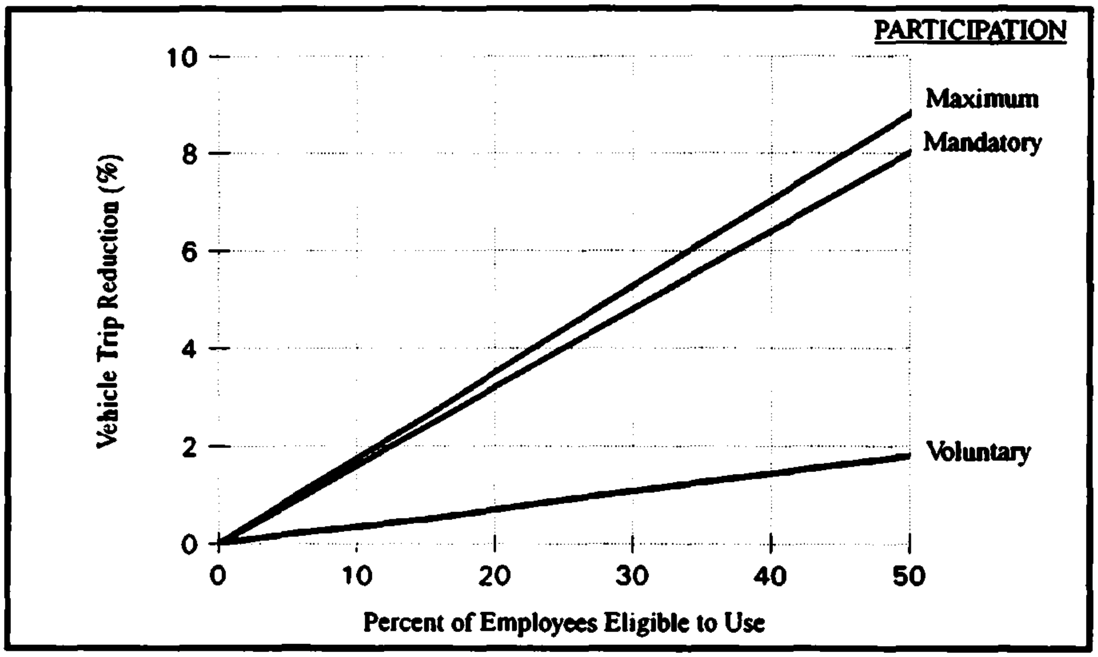
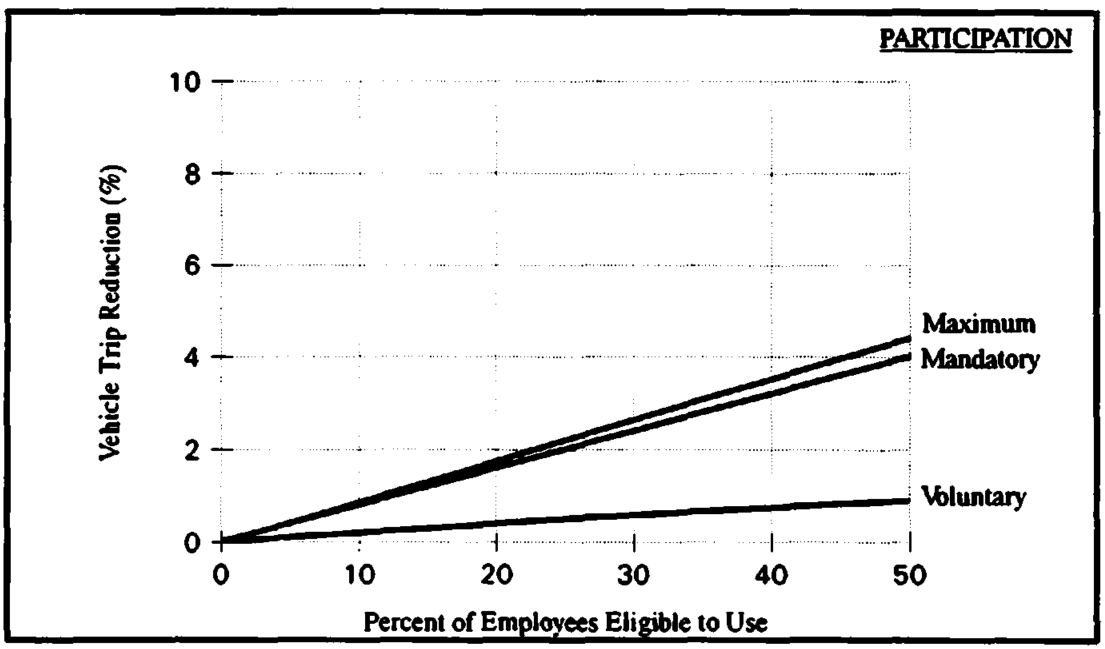


Figure 3.3-11B
9-80 Compressed Work Week



When an employee "telecommutes", the assumption is that the vehicle trip that would have been made to the work site has been eliminated. The trip reduction on the "average day" therefore is dependent on the number of days per week that the employee telecommutes -- so, the number of days is a parameter to be considered when projecting impact.

Figures 3.3-12A, B and C plays out what this option could mean in terms of vehicle trip reduction. As with compressed work weeks, it has been assumed that telecommuting would be most viable with office/professional/white-collar employment, since non-office employees would typically have to be physically present at the work site. Second, it is assumed that of all persons offered the option of telecommuting, 22 percent will accept and utilize the option.

There are three Figures in 3.3-12 (A, B, C), with a separate figure for each participation possibility: Maximum, Mandatory and Voluntary. Within each figure, then, the detail corresponds to both the percent of employees to whom the option would be available, as before, and the *number of days that the option would be exercised -- from one to five days.* Thus, under mandatory conditions, if as many as 50 percent of [office] employees were offered a telecommute option, trip reductions ranging from 2 percent to 8 percent would be realized if telecommuting occurred on an average of one day to five days per week, respectively. If the policy were to be implemented under Voluntary conditions, the range of trip reduction effectiveness would fall to the 0.4 percent to 2 percent range.

3.3.3 Effectiveness of TDM Programs

The intent of the presentations in Section 3.3.3 above was to illustrate the range of trip reduction impacts achievable through the broad range of *individual* TDM strategies which are in the planning menu. Some groupings of measures were presented to suggest competitive and synergistic effects, but primarily, the objective was to portray strategies according to their own potential achievements -- in effect, a sensitivity analysis of what each strategy can do at different levels of stringency, in different AVR environments, and under different regulatory conditions.

The real potential of TDM, however, lies in the strategic grouping of measures into "programs" of reinforcing actions. This is good advice from both a technical and a practical point of view:

- The biggest impacts from TDM *technically* come when actions are synergistically combined, in which case the "whole" is frequently greater than the sum of the "parts". In fact, it is erroneous to try to combine the impacts of the individual actions above by just "adding" them together, since their

Figure 3.3-12A
Maximum Participation

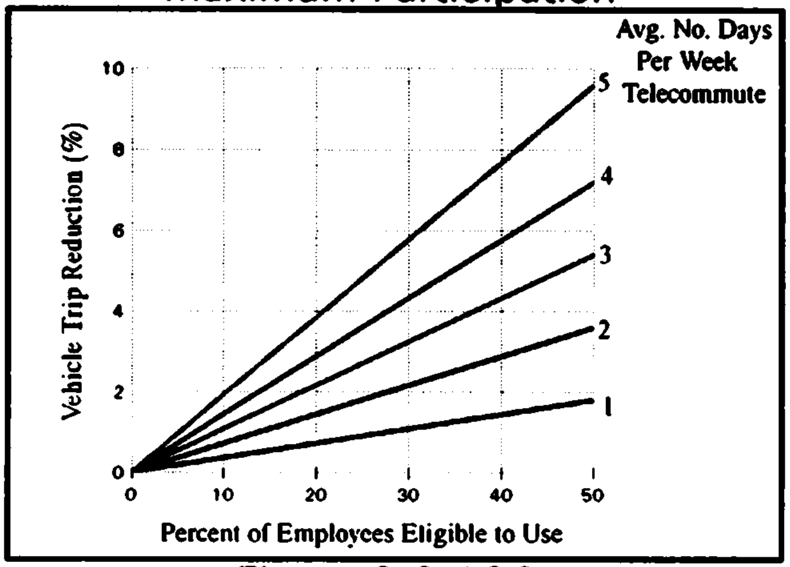


Figure 3.3-12B
Mandatory Participation

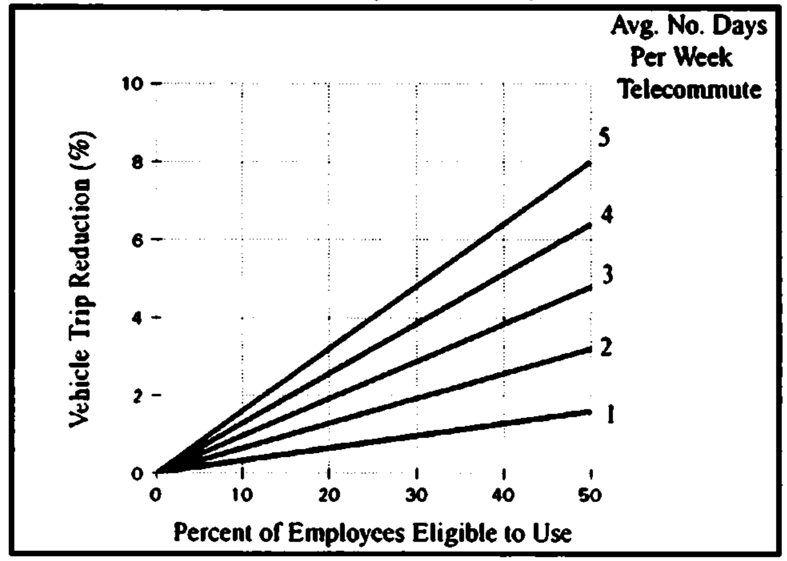


Figure 3.3-12C
Voluntary Participation

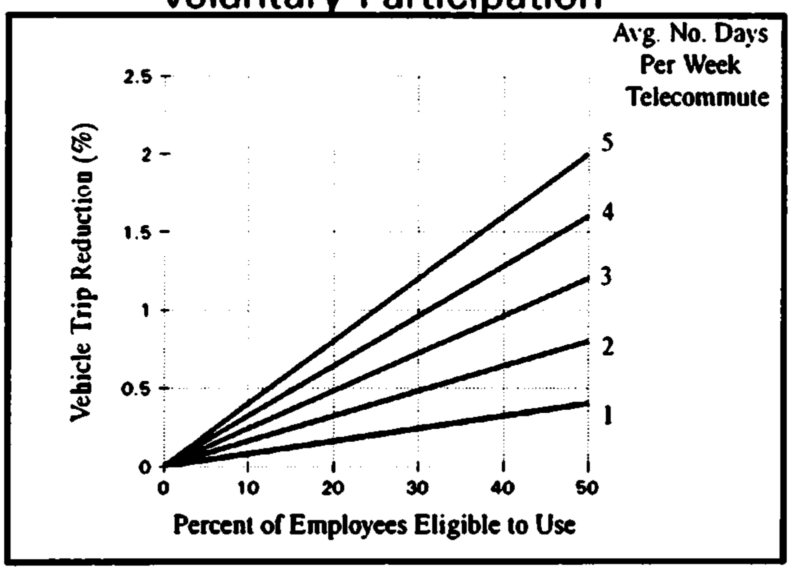


Figure 3.3-12
Telecommuting

interactions are complex and counter-intuitive; a statistical procedure is necessary to perform this combination.

- From a *practical* standpoint, balance in a TDM program is necessary to achieve acceptance and desired impact. Generally, it would be unacceptable to encourage travel through incentive/disincentive measures to change behavior without providing them with acceptable alternatives to use.

The manner in which TDM measures can be combined into programs is almost limitless. The TDM program planner can draw from any or all of the measures defined above, and can apply them in any combination and at any level of stringency. While this may seem an impossible task, it is really not as overwhelming as it may have once been. First, the portrayal of individual strategy effects in the previous section begins to suggest which measures are most appropriate for which types of settings and levels of desired trip impact. Second, there are tools and guidance materials available through this study that are designed to simplify this process of program design. The Employer-Based TDM Guidance Manual and the Government-Based TDM Guidance Manual are both comprehensive guides that will assist the employer or public agency in developing and reviewing program "packaging" options. Also, the TDM Evaluation Model is available to interested users for development and evaluation of programs with great flexibility on a microcomputer.

Because there are so many ways in which TDM programs can be defined in terms of measures and setting, this section serves merely to illustrate how some typical programs can be formulated and what their effects might be. These are **comprehensive programs**, which mean they are applied at an areawide level and include a range of actions that are implemented by both employers and areawide transportation agencies.

Tables 3.3-9 through 3.3-11 present a set of comprehensive TDM programs that combine a full set of measures designed to improve the base of alternative modes, provide a system of incentives and disincentives, and offer various alternative work arrangements. The program designs are the same in each of the three tables; the difference is that Table 3.3-9 shows results that would occur if these measures were implemented in a Low AVR setting, while Table 3.3-10 reflects results in a Medium AVR setting and Table 3.3-11 reflects the High AVR setting.

TABLE 3.3-9

Sample TDM Programs: *Low AVR Setting*

Regulatory Requirement	Voluntary		Mandatory		Maximum	
Impact Range	Low	High	Low	High	Low	High
EMPLOYER-BASED MEASURES						
EMPLOYER SUPPORT MEASURES						
Transit Program Level	L2	L3	L2	L3	L2	L3
Carpool Program Level	L2	L3	L2	L3	L2	L3
Vanpool Program Level	L2	L3	L2	L3	L2	L3
ALTERNATIVE WORK ARRANGEMENTS (% eligible)	5	10	5	10	5	10
PREFERENTIAL PARKING (MINUTES)						
SOV Penalty	1	2	1	2	2	2
CP2 Savings	1	2	1	2	2	2
CP3 Savings	2	3	2	3	3	3
CP4 + Savings	3	4	3	4	4	4
ECONOMIC MEASURES						
SOV Surcharge	$.50	$1	$.50	$1	$.50	$1
Transit Subsidies (per trip)	$.25	$.50	$.25	$.50	$.25	$.50
HOV Subsidies: (per vehicle)						
CP2 Subsidy	$1	$2	$1	$2	$1	$2
CP3 Subsidy	$1.5	$3	$1.5	$3	$1.5	$3
CP4 + Subsidy	$2	$4	$3	$4	$3	$4
AREAWIDE MEASURES						
Transit IVT (Mins.)	2.5	5	2.5	5	2.5	5
Transit OVT (Mins.)	2.5	5	2.5	5	2.5	5
HOV Lanes minutes savings occupancy level	 2.5 2 +	 5 2 +	 2.5 2 +	 5 2 +	 2.5 2 +	 5 2 +
PERCENT VEHICLE TRIP REDUCTION	4.9	11.8	14.4	36.5	15.7	39.8

TABLE 3.3-10

Sample TDM Programs: *Medium AVR Setting*

Regulatory Requirement	Voluntary		Mandatory		Maximum	
Impact Range	Low	High	Low	High	Low	High
EMPLOYER-BASED MEASURES						
EMPLOYER SUPPORT MEASURES						
Transit Program Level	L2	L3	L2	L3	L2	L3
Carpool Program Level	L2	L3	L2	L3	L2	L3
Vanpool Program Level	L2	L3	L2	L3	L2	L3
ALTERNATIVE WORK ARRANGEMENTS (% eligible)	5	10	5	10	5	10
PREFERENTIAL PARKING (MINUTES)						
SOV Penalty	1	2	1	2	2	2
CP2 Savings	1	2	1	2	2	2
CP3 Savings	2	3	2	3	3	3
CP4 + Savings	3	4	3	4	4	4
ECONOMIC MEASURES						
SOV Surcharge	$.50	$1	$.50	$1	$.50	$1
Transit Subsidies (per trip)	$.25	$.50	$.25	$.50	$.25	$.50
HOV Subsidies: (per vehicle)						
CP2 Subsidy	$1	$2	$1	$2	$1	$2
CP3 Subsidy	$1.5	$3	$1.5	$3	$1.5	$3
CP4 + Subsidy	$2	$4	$3	$4	$3	$4
AREAWIDE MEASURES						
Transit IVT (Mins.)	2.5	5	2.5	5	2.5	5
Transit OVT (Mins.)	2.5	5	2.5	5	2.5	5
HOV Lanes						
minutes savings	2.5	5	2.5	5	2.5	5
occupancy level	2 +	2 +	2 +	2 +	2 +	2 +
PERCENT VEHICLE TRIP REDUCTION	8.5	17.6	21.2	42.0	22.8	44.8

TABLE 3.3-11

Sample TDM Programs: *High AVR Setting*

Regulatory Requirement	Voluntary		Mandatory		Maximum	
Impact Range	Low	High	Low	High	Low	High
EMPLOYER-BASED MEASURES						
EMPLOYER SUPPORT MEASURES						
Transit Program Level	L2	L3	L2	L3	L2	L3
Carpool Program Level	L2	L3	L2	L3	L2	L3
Vanpool Program Level	L2	L3	L2	L3	L2	L3
ALTERNATIVE WORK ARRANGEMENTS (% eligible)	5	10	5	10	5	10
PREFERENTIAL PARKING (MINUTES)						
SOV Penalty	1	2	1	2	2	2
CP2 Savings	1	2	1	2	2	2
CP3 Savings	2	3	2	3	3	3
CP4 + Savings	3	4	3	4	4	4
ECONOMIC MEASURES						
SOV Surcharge	$.50	$1	$.50	$1	$.50	$1
Transit Subsidies (per trip)	$.25	$.50	$.25	$.50	$.25	$.50
HOV Subsidies: (per vehicle)						
CP2 Subsidy	$1	$2	$1	$2	$1	$2
CP3 Subsidy	$1.5	$3	$1.5	$3	$1.5	$3
CP4 + Subsidy	$2	$4	$3	$4	$3	$4
AREAWIDE MEASURES						
Transit IVT (Mins.)	2.5	5	2.5	5	2.5	5
Transit OVT (Mins.)	2.5	5	2.5	5	2.5	5
HOV Lanes minutes savings occupancy level	2.5 2 +	5 2 +	2.5 2 +	5 2 +	2.5 2 +	5 2 +
PERCENT VEHICLE TRIP REDUCTION	12.6	21.1	30.4	43.5	32.6	46.8

The sample programs include the following elements:

RANGE OF IMPACT

The programs have been structured to show the level of vehicle trip reduction that would occur if the program measures were implemented in a Voluntary or Mandatory environment, with the third column reflecting the ideal of Maximum (100 percent) employer participation. Under each of these three regulatory conditions is a Low and High range designation; program efforts basically double in going from the Low to the High range, with everything else remaining the same.

EMPLOYER-BASED MEASURES

There is a full range of employer-based TDM measures specified, including:

- **Employer Support Measures** - Depicts employer support of Transit, Carpooling and Vanpooling programs at the previously-defined levels of effort of L2 and L3.

- **Alternative Work Arrangements** - Allows for participation of, alternately, 5 percent and 10 percent of the work force in each of the following alternative arrangements:

  Flexible Work Hours

  Staggered Work Hours

  4/40 Compressed Work Week

  9/80 Compressed Work Week

  Telecommuting (average of 1 day per week)

- **Preferential Parking Policies** - Details a parking management plan where SOVs are penalized with a walk penalty of 1 minute to 2 minutes over current conditions, while HOVs are afforded closer-in/reserved parking where they save between 1 and 2 minutes if a 2-person carpool, between 2 and 3 minutes if a 3-person carpool, and between 3 and 4 minutes if a carpool of 4 or more persons or a vanpool.

- **SOV Surcharges** - Administered probably through parking charges, ranging from $0.50 to $1 per day.

- **Transit Subsidies** - Range from $0.50 to $1 per day (shown as $0.25 and $0.50 per trip).

- **HOV Subsidies** - Range from $0.50 to $1 per day *per person*.

AREAWIDE MEASURES

These are TDM measures that would be implemented by an areawide transportation (i.e., government) agency. They include:

- **Transit Service Improvements** - Consist of improvements in coverage and service that result in both In-Vehicle and Out-of-Vehicle time savings of between 2.5 minutes and 5 minutes to the average user over what they are experiencing currently.

- **HOV Lane Savings** - Delivers, through a presumed network of HOV priority treatments, time savings of between 2.5 and 5 minutes to all transit users and HOV users with 2 or more occupants.

The projected impacts of these programs in terms of vehicle trip reduction were calculated using the TDM Evaluation Model and are shown at the bottom of each table. They show a range of reduction of:

- From 4.9 percent to 11.8 percent for Voluntary programs in the Low AVR case, from 8.5 percent to 17.6 percent in the Medium AVR case, and from 12.6 percent to 21.1 percent in the High AVR case. The reviewer should note that, while these programs are voluntary and represent modest rates of participation, that the programs have been structured to include pricing actions; this typically does not occur in voluntary settings, hence, the projected impacts are probably optimistic. *The reader should also note that these trip reductions relate only to the Home-Based Work trips to which the TDM programs have been targeted; to ascertain the impact on overall traffic in the study area, it is necessary to merge these results into the travel inventory for the area (Non-Work trips and Work trips with destinations outside the impact area).*

- From 14.4 percent to 36.5 percent for Mandatory programs in the Low AVR case, from 21.2 percent to 42.0 percent in the Medium AVR case, and from 30.4 percent to 43.5 percent in the High AVR case.

These are fairly significant changes in travel behavior and trip reduction that can be brought about by TDM, and none of the measures are at and excessive level in order to produce the net impact. It is the combination of measures that contributes to the overall effect, where, for the mandatory level programs, it is possible to conceive of areawide trip reduction impacts from TDM that are similar to those evidenced in the empirical examples presented in Section 3.2 earlier. The primary ingredient is that it is necessary to make sure that particular actions are implemented by as many employers as possible; for this, it is necessary to have a well-crafted regulatory instrument. This will be discussed at greater length in Section 3.5.

3.4 COST EFFECTIVENESS OF TDM

The preceding analyses provide substantial evidence that TDM, when properly designed and implemented, can be quite effective in altering travel behavior and reducing the demand for vehicle travel. This section addresses a frequently asked associated question: "Is TDM effective from a cost-benefit standpoint"? If we are to use TDM to augment the practice meeting of mobility needs exclusively through new highway capacity, and challenge long-held freedoms of individuals in expressing their mobility in terms of vehicular travel, can we find justification in the economics for such a radical change in transportation policy?

The answer to these questions must consider the costs and cost savings associated with TDM versus the more conventional "supply-side" approaches to three different groups:

- **Society**
- **Employers**
- **Individual Travelers**

This section performs an assessment of the costs and savings to each of these groups, and results in some important overall conclusions as to the cost-effectiveness of Travel Demand Management.

3.4.1 Cost to Society

"Society" is defined as the collective body that pays for transportation infrastructure, service and programs. While governments and their transportation agencies make the decisions on the allocation of resources to these programs, the resources themselves are furnished by taxpayers. And, because revenues derived from taxes come from other productive uses in society, both public and private, it is important to know whether these resources are being spent in the most cost efficient manner.

Consider the process by which new highway investment decisions are made. The decision to make a capital investment in a new highway, or to alter or upgrade a highway, can stem from any of the following reasons:

- **Economic Development/Connectivity:** Transportation access is viewed as a catalyst in opening up new areas for development, or providing connectivity between areas that allows movement of goods and people with greater efficiency.

- **Safety/Rehabilitation:** A roadway may be of an outdated design, or in a state of disrepair, so improvements are made to upgrade its condition.

- **Alleviate Congestion:** Over time, a roadway may realize increased demand resulting in crowding of the facility, so improvements are made to widen the facility, relocate the facility, or build an entirely new facility to meet the added demand.

Because of the different motivations between these three different types of highway investment programs, the criteria are somewhat different. Obviously, in the case of Safety and Rehabilitation projects, the concern is that travel may continue and is as safe as possible, so these expenditures may not be scrutinized in economic efficiency terms (other than preservation of the investment).

In the case of Economic Development, connectivity and access become the principal criteria, and the decision is being made to "stimulate" growth, not accommodate a travel demand that has already been identified. The hope for an investment such as this is that it will stimulate travel through greater economic activity, so generally, traffic problems and efficiency are not given major consideration. In rural areas, this is perhaps a valid position. In urbanized areas, it may not be as valid if the highway is going to generate new development and travel demand, and that demand may lead to inefficient use of the facility, eventual crowding, and the need for further construction.

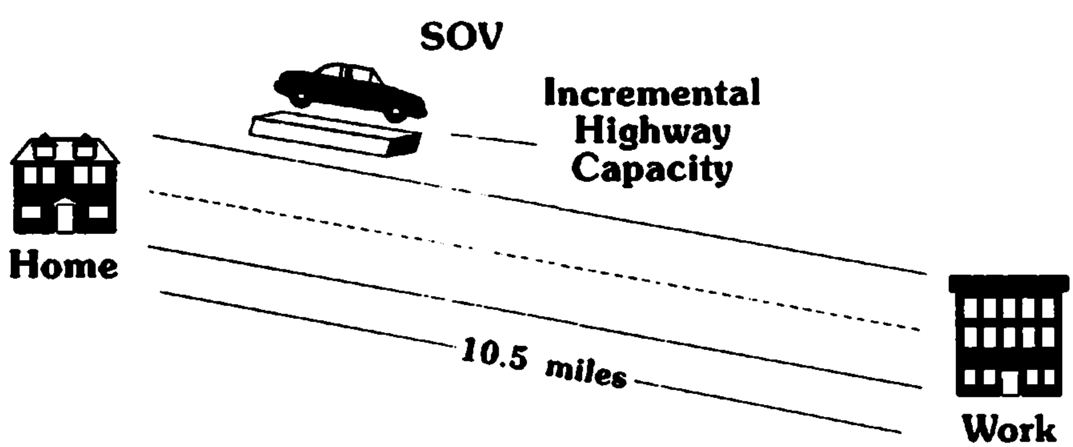
In the third case, capacity enhancements to alleviate congestion, the investment is being made entirely to accommodate additional traffic demand, ***measured typically in terms of vehicle travel demand.*** In most of these instances, the capacity of the facility is challenged most by peak hour loadings, when most of the commuting trips are occurring. Outside of the peak hour or peak period, the facility typically has enough carrying capacity to meet all of its other travel demands. Hence, these investment decisions are made primarily to support peak hour/peak period traffic demand, when travel efficiency is at its lowest. Commute trips are consistently the lowest occupancy of all trip types. So, when a decision is made to expand capacity for traffic, it is typically expending resources to accommodate the most inefficient use of the infrastructure that is encountered.

An analysis was performed to estimate the economic cost to society to accommodate the demand for additional peak period highway capacity. To do this, a methodological procedure was developed which calculates the *incremental cost to construct and maintain the highway capacity necessary to carry an individual commuter on a typical trip to work in an urbanized area.* This methodology is pictured in Figure 3.4-1.

Figure 3.4-1

COST TO SOCIETY

To Supply Highway Capacity to Serve Work Trip



Simply stated, what the methodology tries to measure is this: Assume that an individual traveler wishes to make a trip from home to work on a highway network that is *already congested to the point of capacity, such that the addition of one more trip would represent a decline in service for the existing travelers.* The question posed is: What would it cost to build enough new highway to accommodate the demand of this one additional trip, in terms of the amortized capital cost as well as the ongoing costs of operation and maintenance? To estimate the cost of this marginal "increment" of service, the following assumptions were made:

- **Trip Length:** That the one-way trip distance was 10.5 miles, as reported in the 1990 Nationwide Personal Transportation Survey.

- **Type Facilities:** That the trip would occur one-half on Freeways (with carrying capacity of 1,800 vehicles per hour), and one-half on arterials (capacity of 1,200 vehicles per hour).

- **Time Spread:** That the trip demand would be spread over a two-hour peak period (a less costly assumption than if the trip was concentrated into a single peak hour only).

- **Directionality:** That the capacity would be used equally in both directions of flow, i.e., that it would not be empty half the time in the reverse peak direction.

Using these assumptions, a cost estimate of the value of this new increment of capacity was developed. Unit cost measures were taken from detailed statistics derived in the ***Maryland Statewide Commuter Assistance Study*** (COMSIS Corporation and R.H. Pratt, Consultant for the Maryland Department of Transportation, 1990) and updated to 1992 levels. Right-of-Way and construction cost indices of $12.5 million per lane mile for freeways, and $76.4 million per lane mile for arterial facilities, were used to value the calculated lane miles of new capacity for the additional single-occupant vehicle trip. These capital costs were amortized over a presumed 30-year service life at a 10 percent social rate of interest (as used by the Federal Highway Administration). Additionally, operation and maintenance (O&M) costs of $8,300 per lane mile per year were factored into the calculation (in terms of magnitude, the O&M costs are only a small fraction of the total cost). From this calculation, illustrated in Figure 3.4-2, it was determined that the cost to provide the additional capacity to accommodate an incremental commute trip in an SOV was $6.75 per *one-way person* trip.

It should be noted that the assumptions underlying the SOV cost estimate reflect the most favorable conditions, in terms of arriving at the lowest estimate of cost. It is assumed that all travel is on high-class roadways (arterial or greater), which carry greater capacities. The assumptions as to two-hour peak utilization and bi-directional loading also both respectively, *halve* the cost estimate over what might be a more conventional assumption. And finally, the unit costs for construction and right-of-way both represent the low end of the cost scale, reflecting the costs more typically associated with expansions in areas where right-of-way is available, rather than new construction in scarce right-of-way areas.

Figure 3.4-2
Highway Cost Assumptions (1992 Dollars)

Average Trip Length:	**10.5 Miles (1990 NPTS)**
Type Facilities:	**1/2 Freeway (1,800 VPH Capacity)** **1/2 Arterial (1,200 VPH Capacity)**
Time Spread:	**2 Hour Peak Period**
Directionality:	**Capacity Used Equally Both Directions**
Costs:	**ROW & Construction** **$12.5 mil per L.M. - Freeway** **$ 7.4 mil per L.M. - Arterial** **Amortization** **30 years @ 10%** **O&M** **$8,300 per L.M. per year**

Cost of Peak Period SOV Trip: $6.75 per One-Way Trip

A similar type of analysis was performed to approximate the cost to society to transport the same person by public transit. The taxpayer cost to supply the same trip through transit was determined through the following assumptions and relationships:

- **Highway Capacity Cost:** It was assumed that the trip would be made on bus transit, in which the vehicle would exert a capacity demand on the roadway system of 1.6 times the vehicle space required by the SOV, but carrying an average of 30 people in the vehicle.

- **Operating Cost:** An operating cost of $0.37 was determined from Federal Transit Administration 1991 Section 15 statistics for national bus-only transit systems.

- **Capital Cost:** Capital cost was estimated assuming a value of $160,000 per vehicle and a service life of 1 million miles, resulting in a cost of $0.16 per mile.

- **Revenue:** Also from FTA Section 15 sources, it was determined that the average passenger revenue to offset the operating and capital costs was $0.17 per mile.

Assuming the same commute trip length of 10.5 miles, this calculation, which is illustrated in Figure 3.4-3, results in an estimate of a $4.10 one-way trip net cost to society if the same person travels to work by transit.

Figure 3.4-3
Transit Cost Assumptions (1991 Costs)

Highway Cost:				
$ 6.5 / 10.5 mi	x	1.6 Vehicle Equiv. / 30 Passengers	=	$0.034 per mile
Transit System Cost:				
Operating Cost:			=	$0.37 per mile
Capital Cost:			=	$0.16 per mile
		Direct Cost:		$0.564 per mile
Cost of Transit Trip:		**10.5 miles x $0.564**	**=**	**$5.92**
Revenue:				
Fare Revenue:			=	$0.173 per mile
Net Cost:			=	$0.391 per mile
Net Cost of Transit Trip:		**10.5 miles x $0.391**	**=**	**$4.10**

The following table compares the cost of supplying a 10.5 mile work trip by SOV to the principal alternative modes: transit (as just discussed), carpool, and vanpool.

To review the comparative costs, it would appear that transit, though operating at a net cost to society (that exceeds its revenue taken in fares) of $4.10, is still less expensive by $6.75 - $4.10 = $2.65 per one-way trip, or $5.30 per day, compared to providing the same mobility through the SOV.

The other travel alternatives are even more cost effective. If the same individual trip were made by carpool, and that carpool carried an average of 2.5 passengers, the cost to society to provide the transportation capacity for the 10.5 mile commute trip would be $6.75/2.5 passengers or $2.70 per one-way trip. This represents a savings of $4.05 per one-way trip, or $8.10 per day.

Per Person Per Daily One-Way Trip

	Direct Social Cost	Cost Savings
Drive Alone:	$6.75	-------
Transit:	$4.10	$2.65
Carpool: (2.5 pass.)	$2.70	$4.05
Vanpool: (12 pass.)	$0.56	$6.19

If the same person were to travel by a 12-passenger vanpool, which we assume would exert the same vehicle space demand on the highway, the 10.5-mile reference trip would cost society only $6.75/12 passengers, or $0.56 per person per one-way trip. This represents a savings of $6.19 per one-way trip, or $12.38 per day.

Clearly, there are substantial savings that would result from meeting mobility needs of individuals through diversion from SOV to alternative modes that make more efficient use of scarce highway capacity.

3.4.2 Costs to Employers

The second area where cost effectiveness is relevant is with employers who implement TDM programs. A good cross-section of experience is represented in the family of case studies presented in Section 3.2. These employers constitute the essential range of experience, in terms of locational setting, size and type of activity, motivation to perform TDM, and combinations of measures.

Cost and cost savings for these employer programs were ascertained through information obtained from the employers themselves, although in some instances the information was either not known or regarded as confidential by the employer; in instances where it was not known, an effort was made to estimate the cost from cost indices developed for similar situations elsewhere. It should be noted, however, that the need to perform such indirect estimates was not common in this analysis.

Information was developed to support the following cost measures:

1. **Direct and Indirect Costs Associated with TDM Program:**

   Administrative -- Staff and equipment costs to plan/implement (annualized) and operate the program.

   Marketing and Promotion -- Costs to develop and supply informational materials, presentations and promotional offers/events.

   Outside Services -- Cost for program support from outside sources, including consultants, surveys, matching services, auxiliary staff, etc.

   Transportation Services -- Expenditures to acquire, supply or operate transportation services or supporting facilities to employees.

   Transportation Subsidies -- Cost of supplying financial assistance to encourage use of alternative modes.

2. **Cost Savings:**

   Transportation Revenues -- Any revenues received from the imposition of parking charges or fees, or payments from users of vanpool or other services or programs.

   Parking Expense -- Costs avoided in supplying parking to employees, measured in terms of lot/garage space which did not have to be constructed or maintained, or lease or subsidy payments of parking at facilities not owned by the employer.

   Opportunity Cost of Land -- Savings resulting from freeing of land dedicated to parking for other purposes.

These data were compiled to the extent of their availability and summarized in Table 3.4-1. The table displays the employer program sites, in declining order of their estimated vehicle trip reduction performance, and cites the strategies that make up

Table 3.4-1

COST EFFECTIVENESS SUMMARY: EMPLOYER TDM PROGRAMS

SITE	EMPLOYER/PROGRAM CHARACTERISTICS			EMPLOYER ECONOMICS			
	Number Employees	Trip Reduction	TDM Strategies Applied	Annual Direct Costs (per daily one-way trip)	Annual Savings (per daily one-way trip)	Annual Net Cost (per daily one-way trip)	Daily Net Cost per Employee
1. **Travelers Insurance** Hartford, CT	10,000	3,930 (47.9%)	· Restricted Parking · Charge for Parking, w/Inverted Fee Structure · Transit Subsidies · Vanpool Program	$1,124,400** ($.55)	$1,179,000 ($.58) $8,253,000 ($4.03)	-$54,600 (-$.03) -$7,128,600 (-$3.48)	-$.02 -$2.73
2. **U.S. WEST** Bellevue, WA	1,150	436 (47.1%)	· Restricted On-site Parking · Charge for Parking, w/Inverted Fee Structure · Reserved HOV Spaces · Flextime · Coordinator	$27,625 ($.12)	$113,044 ($.50)	-$85,419 (-$.38)	-$.28
3. **Nuclear Regulatory Commission** North Bethesda Montgomery Co., MD	1,400	535 (41.6%)	· Restricted Parking · Charge for Parking · Guaranteed Parking for Carpools · County-supplied Transit Subsidies	$35,506 ($.13)	$772,200 ($2.77)	-$736,694 (-$2.64)	-$2.01
4. **GEICO** * Friendship Heights Montgomery Co., MD	2,500	965 (38.6%)	· Restricted Parking · Charge for Parking · Free CP/VP Parking · Subsidized VP Program · Reserved CP/VP Parking · Transit Subsidies w/County Match	$162,875 ($.33)	$752,700 ($1.50)	-$589,825 (-$1.17)	-$.90

** Not FHWA Case Study*
*** No information on employer administration/program costs*
**** Represents market value of land*

Table 3.4-1 (Continued)

COST EFFECTIVENESS SUMMARY: EMPLOYER TDM PROGRAMS

SITE	EMPLOYER/PROGRAM CHARACTERISTICS			EMPLOYER ECONOMICS			
	Number Employees	Trip Reduction	TDM Strategies Applied	Annual Direct Costs (per daily one-way trip)	Annual Savings (per daily one-way trip)	Annual Net Cost (per daily one-way trip)	Daily Net Cost per Employee
5. **CH_2M Hill** Bellevue, WA	400	133 (35.7%)	· $40 Transp. Allowance · Charge for Parking · Carpool Free Parking · Transit Subsidy	None	$31,680 ($.33)	-$31,680 (-$.33)	-$.30
6. **State Farm** Orange Co., CA	980	276 (30.4%)	· Carpool Subsidies · Rideshare Program · Subsidized Van Service	$107,181** ($.75)	$1,218,750***	$107,181 ($.75)	$.42
7. **Pacific Bell** Bishop Ranch, CA	6,900	1,394 (27.8%)	· Restricted Parking · Full-time On-site Coordinator · Rideshare Matching Program · Vanpool Program · Contract Shuttle · Relocation Assistance · Flextime	Unknown**	$239,768 ($.34) $913,070 ($1.29)		Unknown
8. **Hartford Steam Boiler** Hartford, CT	1,100	197 (26.5%)	· Restricted Parking · Charge for Parking, w/Inverted Fee Structure · Vanpool & Transit Subsidies	$163,296** ($1.59)	None	$163,296 ($1.59)	$.57

* *Not FHWA Case Study*
** *No information on employer administration/program costs*
*** *Represents market value of land*

Table 3.4-1 (Continued)

COST EFFECTIVENESS SUMMARY: EMPLOYER TDM PROGRAMS

SITE	EMPLOYER/PROGRAM CHARACTERISTICS			EMPLOYER ECONOMICS			
	Number Employees	Trip Reduction	TDM Strategies Applied	Annual Direct Costs (per daily one-way trip)	Annual Savings (per daily one-way trip)	Annual Net Cost (per daily one-way trip)	Daily Net Cost per Employee
9. Swedish Hospital Seattle, WA	2,500	387 (26.1%)	· Restricted Parking · Charge for Parking · Carpool & Transit Subsidy · Contract Transit Subsidy · Vanpool Startup Subsidy · Guaranteed Ride Home · Flexible Work Hours	$585,800 ($2.89)	$1,259,600 ($6.21)	-$673,800 (-$3.32)	-$1.03
10. Bellevue City Hall Bellevue, WA	567	127 (25.8%)	· Charge for Parking · Free Parking for HOVs · Priority HOV Parking · Alternate Mode Subsidies	$52,116 ($.78)	$106,200 ($1.60)	-$54,084 (-$.82)	-$.36
11. San Diego Trust & Savings San Diego, CA	500	76 (22.7%)	· Parking Subsidy, Higher for HOVs · Transit Subsidy · Ride Matching · Flexible Work Hours	$210,300 ($5.30)	$50,160 ($1.26)	$160,140 ($4.04)	$1.23
12. Pasadena City Hall Pasadena, CA	350	90 (21.0%)	· Parking Fees · Parking Subsidy/HOVs · Transportation Allowance · Free Transit Pass · Vanpool Subsidies · Bike/Walk Subsidies · Guaranteed Ride Home · Childcare Subsidy	$317,500 ($6.75)	$152,500 ($3.24)	$165,000 ($3.51)	$1.81

* *Not FHWA Case Study*
** *No information on employer administration/program costs*
*** *Represents market value of land*

Table 3.4-1 (Continued)

COST EFFECTIVENESS SUMMARY: EMPLOYER TDM PROGRAMS

SITE	EMPLOYER/PROGRAM CHARACTERISTICS			EMPLOYER ECONOMICS			
	Number Employees	Trip Reduction	TDM Strategies Applied	Annual Direct Costs (per daily one-way trip)	Annual Savings (per daily one-way trip)	Annual Net Cost (per daily one-way trip)	Daily Net Cost per Employee
13. **TransAmerica** Los Angeles, CA	2,700	377 (20.0%)	· Charge for Parking · HOV Parking Discounts & Subsidies · Vanpool Assistance · Preferential Parking · Transit Subsidy	$265,100 ($1.35)	$650,000 ($3.30)	-$384,900 (-$1.95)	-$.55
14. **ARCO** Downtown L.A., CA	1,500	341 (19.1%)	· Charge for Parking · Transportation Allowance · CP/VP Parking Subsidy · Vanpool Subsidy · Active R/S Program · Guaranteed Ride Home	$363,300 ($2.04)	$175,956 ($.99)	$187,341 ($1.05)	$.48
15. **Varian** Palo Alto, CA	3,200	490 (17.7%)	· On-Site, Discount Transit Pass Sales · Award Program for Transit/HOV Users · Transportation Coordinator · Bike/Walk Facilities	$102,123 ($.40)	None	$102,123 ($.40)	$.12
16. **AT&T** Pleasanton, CA	3,890	486 (13.4%)	· Restricted Parking · Rideshare Promotion & Matching · Preferential Parking · Flextime	$21,250 ($.09)	$86,190 ($.34) $327,520 ($1.29)	-$64,940 (-$.26) -$306,270 (-$1.20)	-$.06 -$.30
17. **Ventura County Government** Ventura County, CA	1,850	325 (13.0%)	· "Bonus Point" Subsidy · Guaranteed Ride Home · Preferential Parking · Bike/Walk Facilities	$223,500 ($1.31)	None	$223,500 ($1.31)	$.46

* *Not FHWA Case Study*
** *No information on employer administration/program costs*
*** *Represents market value of land*

Table 3.4-1 (Continued)

COST EFFECTIVENESS SUMMARY: EMPLOYER TDM PROGRAMS

SITE	EMPLOYER/PROGRAM CHARACTERISTICS			EMPLOYER ECONOMICS			
	Number Employees	Trip Reduction	TDM Strategies Applied	Annual Direct Costs (per daily one-way trip)	Annual Savings (per daily one-way trip)	Annual Net Cost (per daily one-way trip)	Daily Net Cost per Employee
18. COMSIS Corporation* Silver Spring, MD	130	10 (10.5%)	· Restricted Parking · Transportation Allowance · CP & TR Subsidies w/County Match	$6,500 ($1.25)	$7,800 ($1.49)	-$1,300 (-$.24)	-$.82
19. 3M Company St. Paul, MN	12,700	1,130 (9.7%)	· Vanpool Assistance · Staggered Work Hours	Unknown	Unknown	Unknown	Unknown
20. Allergan Irvine, CA	1,250	76 (7.0%)	· Subsidized Vanpool Program · 100% Transit Subsidy · Preferential Parking · Paid Holiday HOV Incentive · Comprehensive Employer Support Measures · Flexible Work Hours	$239,950 ($6.05)	$42,000 ($1.06)	$197,450 ($4.99)	$.61
21. UCLA Los Angeles, CA	18,000	828 (5.5%)	· Restricted Parking · Charge for Parking · Vanpooling Program (65 Vans) · Carpool Matching · Campus Shuttle Service · Park-N-Ride Service	$2,428,689 ($5.62)	$662,400 ($1.53) $1,349,640 ($3.13)	$1,766,289 ($4.09) $1,079,049 ($2.50)	$.38 $.23
22. Chevron Concord, CA	2,300	76 (3.7%)	· Transit Shuttle Service · Vanpool Assistance · Rideshare Matching · Preferential Parking · Employer Support · Flexible Work Hours	$38,600 ($.97)	None	$38,600 ($.97)	$.06
TOTAL	56,267	10,161		$1.22	$1.94	-$.72	-$.24

* *Not FHWA Case Study*
** *No information on employer administration/program costs*
*** *Represents market value of land*

their TDM program. The information presented under Employer Economics then illustrates the estimated cost and cost savings associated with the program:

- **Annual Direct Costs:** This column depicts the total annual direct costs associated with running the program, followed by, in parentheses, the resultant cost per trip reduced. To be consistent with the earlier Cost to Society indices, these per-trip costs are presented on a one-way daily trip basis; in other words, the cost per daily round-trip reduced would be double the amount shown in parentheses.

- **Annual Cost Savings:** This second column depicts the cost savings associated with the TDM program effort. Again, these costs reflect revenues generated as a result of the program, as well as employer parking costs avoided. Also, the cost savings per one-way trip reduced are shown in parentheses.

- **Annual Net Cost:** As it implies, this column is the difference of the first two columns, and is the end cost realized by the employer to run the program. If the number is positive, the program is costing the employer a net investment in order to achieve the results desired. If negative, the employer is saving money.

- **Daily Net Cost per Employee:** A unit cost measure that represents the net cost *averaged over all employees.* This is also a <u>daily</u> cost measure, in comparison to the one-way daily trip measure in the previous columns.

Reviewing the results in the table will reveal the following relationships:

- **Direct Cost per Trip Reduced:** The direct cost to operate a TDM program ranges from $0 to $6.75 (Pasadena City Hall) per daily one-way trip removed, with an average for the sample of $1.22 (average weighted by daily trips reduced).

- **Cost Savings per Trip Reduced:** The costs saved by employers range from $0 to $6.21 (Swedish Hospital) per daily one-way trip removed, with an average for the sample of $1.94.

- **Net Cost per Trip Reduced:** The net cost to employers per one-way trip reduced ranges from $4.99 (Allergan) to -$3.22 (Swedish Hospital), with an average of $0.72. So, on average, employers are saving money through TDM programs when all costs are considered.

- **Net Cost per Employee:** Spreading the net cost burden (or savings) for the TDM program over the entire employee base, which is perhaps a better measure of the impact on the employer, shows a range of experience from a high of $1.81

(Pasadena City Hall) to a low of -$2.01 (Nuclear Regulatory Commission) per employee per day, with an average of -$0.24 for the overall sample.

One may reach several conclusions from these findings:

- Overall, TDM programs pose a modest cost to employers, when expressed either in terms of cost per employee or per trip reduced.

- Properly designed, TDM programs can actually save employers money, particularly when the trip reductions produced by the program can be used to offset the high cost of providing parking facilities and/or subsidies to employees.

- Costs vary for many reasons. Some of the programs with the highest trip reductions have some of the lowest direct costs and most rewarding net costs. Conversely, some employers with good results are also putting substantial resources into their programs, and -- unfortunately -- some employers with poor results are also putting substantial resources into their programs.

Generally, TDM programs should not cost the employer a great deal as a comparable business expense, and can in many instances result in a savings. Also, "simple is better" when it comes to TDM program design. Many of these example programs represent substantial employer involvement and investment in "pet programs", which have little direct impact on tripmaking but cost a substantial sum of money to support. For example, there are cases where employers could easily divert employees into carpools, but for private reasons, choose instead to invest heavily in vanpool or transit programs, when those programs are not as well suited to the characteristics of the travel market. Another common example is where employers invest heavily in administrative support and promotional programs, but do not attempt to influence the economic decision of the employee. And still a third example is where employers invest in economic incentive measures, but they are the wrong incentive measures, and/or they do not cease providing incentives to SOV users -- so they are in effect "paying twice".

3.4.3 Costs to Individual Travelers

The final cost analysis is the one posed to individual travelers. Not surprisingly, even individuals realize *monetary* cost savings through the use of non-SOV modes. Using data compiled by the Motor Vehicle Manufacturer's Association in its 1992 *"Cost of Operating an Automobile"* publication, the cost of operating an automobile was found to average $0.458 per mile. This unit cost includes as *operating costs* fuel/oil, maintenance and tires, as well as the *fixed costs* of insurance, licensing, financing and depreciation. It does not include important out-of-pocket costs such as parking or tolls. For the profiled 10.5 mile trip to work, the auto costs the SOV user $4.81 per one-way trip, and $9.62 per day.

If the same person were to commute by an alternate mode, for the same trip length, the comparable costs would be:

- Transit - $1.82, using information from the Federal Transit Administration's Section 15 database for 1991.

- Carpool - $1.92 per person, obtained by dividing the $4.81 per trip for an SOV by the average 2.5 occupants.

- Vanpool - $.40 per person, obtained by multiplying cost-per-person-mile data obtained from Vanpool Services, Inc. (VPSI), times an 10.5 mile trip length. (The reader will sense that this cost seems very small, but must remember that the average vanpool trip is much longer than 10.5 miles, which is being used to standardize this comparison across modes.)

Given these choices, one would wonder why the traveler would not naturally opt for the alternative modes more frequently. The key reasons why the SOV is still preferred are:

- Implicit Costs - Many of the costs of owning and operating an automobile are internalized by the owner, such that the perceived cost for using a car for a work trip is generally limited to out-of-pocket expenses, and to some degree, fuel costs.

- Subsidies - Free or subsidized parking at work sites by employers eliminates the major visible cost of private vehicle operation, and further serves as an encouragement to SOV use.

- Travel Time - Given the present land use patterns and configuration of alternatives, even in high traffic situations, the SOV offers no less quality of service than any of the alternatives, and is much more convenient because of its door-to-door, on-call flexibility.

In conclusion, individual travelers would almost exclusively save money if they used alternative modes. And, if some of the important direct costs of SOV travel were not hidden through subsidies, particularly employer parking, then this cost differential and resultant savings would be much greater and more persuasive. In terms of current economic relationships, however, these costs do not bear on SOV users, and the time advantages associated with using the SOV over the alternatives -- particularly in suburban areas which have been designed around the SOV -- will emphatically steer travelers to the SOV. These travel time advantages are not so much an inherent value of the SOV, but are because the alternative modes, with limited use, also provide secondary service (i.e., more travel time). With proper attention to design, and with greater use, these alternatives could compete more favorably in travel time, such that the cost calculation to the individual would be much more favorable toward non-SOV modes.

3.4.4 Cost-Effectiveness Summary and Implications

The foregoing sections provided evidence that Travel Demand Management concepts can be a cost-effective alternative to traditional supply-side methods of providing mobility and alleviating traffic congestion. Accommodating travel demand through means other than Single-Occupant-Vehicles can result in cost savings to all three major stakeholders:

- Society at Large
- Employers
- Individual Travelers

A summary of the cost impacts to each of these groups is provided in Figure 3.4-4. Some important conclusions can be drawn from these relationships that have a bearing on how TDM might be more effectively promoted and implemented.

Beginning with the highway-based Cost to Society, Figure 3.4-4 recaps that the marginal cost to society to accommodate an additional SOV commute trip on a crowded highway network is $6.75 per daily one-way trip, and $13.50 per day, making it the most expensive method of travel of all the alternatives. This is a conservatively-estimated cost, and one which does not include the individual traveler's expense for owning and operating a motor vehicle. If the same traveler were transported in the next most expensive mode, public transit, the cost to society would be only $4.10 for a one-way trip of the same length, or $2.65 per trip ($5.30 per day) less. If the person were to travel by 2.5-passenger carpool, the cost would fall to $2.70 per trip, and result in a savings of $4.05/trip ($8.00/day) over the SOV. And if transported in a 12-passenger vanpool, the cost would drop to $0.56/trip, and the savings would rise to $6.19/trip ($12.38/day). Moreover, because each of these trips is being compared on a standard trip length of 10.5 miles, given the focus on the SOV, the savings would be even greater if the typical [longer] trip lengths of transit, carpool and vanpool were reflected in the calculation.

Figure 3.4-4
ECONOMICS OF TDM
(10.5 mile work trip)

To Society

Capital and Operating Cost per One-Way Daily Person Trip

SOV:	$6.75
Transit: (less revenue)	$4.10
Carpool: (2.5 passengers)	$2.70
Vanpool: (12 passengers)	$0.56

To The Employer

Direct Cost per One-Way Daily Vehicle Trip Removed

Range: -$1.95 to $5.62

Average: $1.33

Net Cost per One-Way Daily Vehicle Trip Removed

Range: -$3.32 to $4.99

Average: $.43

To The Individual

Cost per One-Way Daily Person Trip

SOV:	$4.81
Transit:	$1.82
Carpool:	$1.92
Vanpool:	$0.40

The implications of these cost differentials begins to have impact when one factors in the magnitude of the number of person trips actually being moved, not only on a given highway, but throughout the nation's infrastructure. And it gives rise to the consideration of "opportunity cost", the economist's notion of opportunity foregone by society by investing in an alternative for which there are much more cost-effective solutions. For the same resources, we can provide much more mobility through decreased use of SOVs. Even small shifts from SOV trips to non-SOV trips can pay enormous dividends, given these cost differentials.

Given this opportunity being foregone by society, the question must be asked: *If society can save anywhere between $5.30 and $12.40 a day on each commute trip shifted from SOV to an alternative mode, would it be worth offering an incentive to SOV users to shift modes?* Technically, society could offer an incentive of up to the cost differential to an SOV user to shift modes, and still save money in the process.

The first place one might search for a response to the reasonableness of this premise is in the employer experience with TDM programs. What has been the experience in how much it costs to cause a traveler to change behavior? The answer, as explored in Section 3.3 and summarized in the middle column of Figure 3.4-4, is quite favorable. The average Direct Cost to 20 employers to reduce a one-way vehicle trip by employees through TDM actions was $1.33, or $2.66 per day. This is about half the amount which society would save if the person shifted to public transit ($5.30/day), and only 1/4 the amount that would be saved if the person switched to vanpool. In other words, there is demonstrated experience on that individual's travel behavior can be shifted by TDM, and can be done so for considerably less than the cost to society to transport them in SOVs.

The policy question is how can these cost/productivity advantages be used to promote action? One approach is to continue to require employers to implement TDM actions, as well as giving them guidance as to their most cost-effective course of action. In the sample of 20 employers, half actually showed net cost savings through application of TDM strategies. Most of the others could have shown net savings as well as higher impacts if they had selected more effective economic-based strategies. So, employers could actually be seen as *benefiting* from TDM, and could probably be led (through policy and incentives) to do so. An approach would be to consider offering tax credits to employers to provide economic stimulus (incentives or disincentives) to employees that would result in shifts from SOV to HOV. From the standpoint of society, every SOV trip demand that is replaced with mobility through a more efficient mode means a savings in resources, which can be used productively for other important purposes.

The third stakeholder is the individual traveler, where the data indicate that even at this level, the SOV is the most expensive mobility alternative available. Earlier discussion indicated how this analysis does not account for another important aspect of travel, *time expenditure*, where the SOV has important advantages over its alternatives in the monolithic travel system that has evolved in urbanized areas, particularly in *sub*urban areas. Were the various major direct costs of SOV use passed on to SOV users, including parking costs, then the cost comparison to the individual would become much less favorable to travelers.

So in conclusion, consideration of the costs of mobility to the three important stakeholder groups -- society, employers, and individual travelers -- indicates that all are paying much more than they need to support a concept of travel mobility defined as travel by SOV. The next and final section will discuss the broader implications of these relationships toward implementation.

3.5 IMPLEMENTATION ISSUES

3.5.1 Overview

Despite the obvious benefits that Travel Demand Management programs can offer in reducing traffic and avoiding costly capital investments, they are still a challenge to implement. The primary reason is that they call upon us to make profound *personal changes* in the way in which we travel and *technical and political changes* in how we accommodate travel demand.

Historically, when we have encountered a transportation problem, we have viewed it as a problem of insufficient capacity, or in other words, that the *physical* transportation system has somehow failed us. Consequently, the solutions we have pursued have been almost exclusively engineering or "supply-side" solutions, such as building or expanding roads, or installing engineering measures to improve flow and safety. Our tradition has been to accommodate society's demand for travel, to the extent of our resources, *and not to challenge or shape that demand except under the most adverse or extenuating of circumstances*, such as a war, a natural disaster, or an energy disruption.

We are now facing a similarly compelling set of conditions that is causing us to look beyond the traditional supply-side approach to solving transportation problems. We do not have either the fiscal resources or physical space to build the often substantial new infrastructure future demand will require. Nor can we continue to ignore the emissions that vehicles on those facilities generate. Further, societal changes demand that we expand transportation options from the relatively limited set most travelers now have. Therefore, we must begin the process of examining, and perhaps reducing, our demand for travel in order to meet our mobility needs and other pressing social goals efficiently.

As we try to alter this traditional course toward a more "balanced" treatment of supply and demand measures, we encounter numerous barriers to the introduction of new ideas or procedures that incorporate demand altering measures:

- Governments, businesses, and individuals perceive TDM as an infringement on their freedoms and preferences, having grown accustomed to what have become conventional lifestyle and operating practices;

- Existing funding programs, institutions, and laws have been tailored and refined to support the status quo; and

- Current laws, practices and land-use patterns provide incentives that reinforce sprawled, disassociated land development patterns and the practice of driving alone, while discouraging efficiency in either choice of job/residence location or travel mode.

These conditions loom as ponderous barriers to individuals or organizations attempting to implement comprehensive transportation solutions, particularly those with TDM elements. The conventional practice is to gauge the potential of a TDM program in terms of *what the barriers will let you do*, rather than what the strategies themselves are capable of doing. Hence, long before a TDM program of any substance is put on the table, the list of potential actions is significantly pared back to accommodate *a priori* assumptions about political or economic acceptability. Usually, only the most conventional and non-threatening measures remain -- generally the measures with the least impact on travel behavior.

This conventional approach, where we consider and attempt to implement only the most cautious and conservative actions, encourages TDM to be something of a self-limiting solution: we don't expect it to do much, so we don't take the steps to cause it to do much, and therefore it doesn't do much and we conclude, reasonably, that it never had the potential to do much. Unfortunately, this cycle continues to define TDM program efforts, for two reasons:

- The types of individuals who are asked to take lead roles in this area are generally not trained or knowledgeable in the science of travel behavior, but rather in marketing and institutional management. Most also carry limited implementational authority in their respective employer or agency; and

- We have lacked solid information on the benefits and costs of alternative "comprehensive" transportation actions, particularly on the potential impacts of TDM actions and how to tap those impacts.

Thus, we are in something of a double bind when implementing TDM. Society is collectively indicating that something must be done to stem growing problems with traffic congestion, air pollution, and a variety of housing, public service and fiscal problems which may be linked to sprawl, but without new taxes. At the same time, we have been ill-positioned in terms of information, skills and social/institutional flexibility to try something "new" that may allow us to attack these problems efficiently at their roots.

Most conventional approaches to TDM implementation start by providing the implementation audience a myriad of legal or organizational options that may be used to formalize and consolidate a TDM initiative. The actual TDM program is projected to "result" from this formal, collaborative process, and is the result of what the new organization feels it is able or willing to do.

The discussion in this section takes a new and rather unique look at the subject of TDM implementation. It suggests that the process be reversed and be driven by information. Decisions on which TDM strategies to implement should be made first, with a clear understanding of needs and the impacts of each strategy. Then, decisions on how to implement the strategies are made, with an understanding of what mechanisms are required for the TDM strategies chosen. This process, that will help you assess what TDM can do for you and what you may successfully implement, is outlined in the following steps:

(1) Determine the true nature and severity of your problem.

(2) Assess where current transportation program plans are likely to lead you in resolving these problems and identify shortfalls where TDM strategies could be appropriate.

(3) Using information such as is contained in this report, explore the range of TDM options available to you and assess the impact they will have on your transportation problem, *ignoring for the moment whether you think they could be implemented or not.*

(4) Study the tradeoffs among the different alternative approaches regarding cost, timing, impact and other criteria. Decide which elements -- TDM and other -- would be most effective to implement.

(5) Then decide what mechanisms -- regulatory and or institutional -- you will need to implement your chosen program.

You might find, if you pursue this methodology, that barriers may be cast in an entirely different light. In consideration of what you want to achieve, and the relative cost and effectiveness of the different mechanisms, you might decide that "insurmountable" barriers are worth challenging. With some creative thought and careful negotiation, you might be able to accommodate, circumvent, or overpower the barriers, either immediately or over time.

It is not the intent of this chapter to provide you with a cookbook-type methodology for TDM implementation. Its principal objective is to give you a perspective on the types of problems you are likely to encounter as you try to implement TDM, and to give you a general framework for working through those challenges. This framework relies heavily on the use of the information and concepts that are contained in other sections of this report.

However, because the actual task of implementation does constitute considerable detailed guidance, a series of Guidance Manuals have been developed in conjunction with this report. Properly used, they will give you the step-by-step procedures to help you assess your situation and develop your program. They also will help you make maximum use of the information in this reference report.

Special Guidance Manuals have been produced on the following topics:

- Employer-Based Transportation Management Programs
- Government-Sponsored Transportation Management Programs
- Market Research and Evaluation
- Legal and Institutional Implementation Mechanisms

How to make most effective use of these aids will become more clear in the balance of this chapter.

3.5.2 Classification of Needs

Your approach to TDM implementation will depend on many factors. Are you a public agency or private organization? What problem(s) do you intend to address with TDM? How serious or real is the problem? How does it present itself? Is it a problem whose effects are already well in evidence, or is it yet to develop? Do groups and individuals affected by the problem support creative and perhaps non-traditional solutions to the problem? What is your responsibility or authority in the situation, that is, what elements do you control and which are out of your control? Answering these questions helps define your particular motivation for considering TDM and your initial constituency for solutions.

An initial fundamental separation in your motivation generally is whether you find yourself on the public or private side of the problem. If you are a government agency or public agency:

- Are you responding to a formal transportation or air quality law or regulation from a higher level of government, and how stringent and immediate is that law or regulation?

- Are you attempting to develop a local response (legal or programmatic) to a traffic congestion problem? If so, is that response motivated by:

  - A genuine need to improve or increase mobility in the face of limited capital resources or opportunities? or

  - Public pressure to take visible action against perceived uncontrolled growth and or traffic?

- Is your focus at an area-wide/subregional level, in an activity center, a corridor, or to mitigate specific hot spots?

If you are a private employer or developer:

- Are you responding to a formal law or regulation from above? If so:

  - How stringent and immediate is that requirement? and

  - What flexibility in terms of approach do you have in responding to the requirement?

- Are you attempting to improve travel options for your employees, or to improve your access to or retain qualified employees?

- Are you, as part of a business community initiative, taking a proactive stance on a set of transportation problems, and is that response a result of:

  - Perception of a genuine problem that is not being adequately addressed by the public sector? or

  - Simply part of a proactive business community campaign to demonstrate "concern" to the local community about growth/traffic issues, or to maintain the appearance of a proactive, healthy business environment to prospective business interests?

While these different situations suggest a complicated set of motives and circumstances, they can probably be reduced to a much less complex scale of needs, ranging from no need to extreme need. Although the scale is more accurately a continuum, to avoid complicating this initial classification, consider a simple three-point scale:

Low Need: There is neither a clear present or future problem, nor a substantial (or any) legal requirement compelling management action.

Moderate Need: The situation represents either a current problem which will dissipate in the future, or a future problem that is not particularly compelling now; it is uncertain that proposed traditional programs will happen or will be sufficient, and if there is a legal requirement, it is not particularly "hard" or binding.

High Need: The situation represents a clear-cut present and future problem, for which there is no obvious/complete solution now underway, and or there is a strong legal requirement to take action.

As a starting point, your position on this scale will suggest how aggressive your course of action will need to be. If you feel that your area classifies as a **Low Need** situation, perhaps all you have to do is build an awareness of potential future problems, and consider installing a process that would guarantee continued smooth operation or allow for contingency measures if conditions dramatically changed. If you are an area in **moderate need**, then some serious assessment of TDM measures would be recommended, but perhaps only a moderate implementation effort might be warranted. If, however, you are in a state of **high need**, you likely will need to examine TDM strategies aggressively and adopt fairly stringent TDM measures.

These recommendations would be similar to those procedures recommended for good physiological health: an apparently healthy condition requires no more than an awareness of potential problems and maintenance of current good health habits, *potentially* serious conditions require an increased awareness and commitment to improved health habits, but serious conditions require immediate and substantial medical attention.

It is tempting to provide guidance that simplistically offers alternative paths corresponding to each of the three positions. However, like the personal health analogy, the layperson probably is not qualified to make such a diagnosis on his own, but is better advised to consider routine but important diagnostic tests to reach an objective assessment of his condition. So it is with TDM. It is common, for reasons of both ignorance or avoidance, to misdiagnose the nature of a transportation problem or the need for a particular course of action. There are some relatively simple procedures that can be performed to determine how serious and imminent the local problem is, the extent to which TDM can be of help, and what implementation procedures would be most effective in helping the local area or entity address its problem.

The remainder of this chapter introduces a process by which you can assess your particular situation. It is meant to be only an introduction, to lay out for you what you need to consider when evaluating your status and options for action. More detailed guidance on how actually to perform the process is provided in two Guidance Manuals, *Employer-Based Programs* and *Government-Based Programs*. These manuals will guide you through simple analyses that will help you accurately gauge your situation and begin to define your TDM program and implementation options.

3.5.3 Road Map of the Implementation Process

As discussed earlier, the conventional process by which groups implement TDM programs is as follows:

(1) A transportation problem is broadly defined, usually at one extreme of a polar scale: it is either a problem that is well advanced, visible and viewed to be out of control, or it is one that has not yet fully materialized and for which no particular urgency is seen in pursuing a "hard" solution.

(2) The next step often is to implement a broad-based legal or institutional response. Typically, this means enactment of a law or ordinance, or the establishment of a new organizational body charged with the responsibility of managing the problem.

This process skips several important steps. First, it fails to define clearly and specifically the severity of the problem or to set tangible goals for resolution of the problem. Thus it is impossible to know what is to be expected of TDM actions. Further, potential solutions are not systematically reviewed. Rather, "blind" faith is placed in the regulation or the management organization to determine the appropriate solution. This presents potentially serious problems. Without tangible goals or solid information on alternatives, it is difficult to define or develop support for an effective program. As a result, numerous barriers are encountered, and little impact is achieved.

The process proposed in this report reverses these steps and provides several needed missing links for a comprehensive, eight-step process that is far more likely to lead to successful TDM implementation.

(1) Identify problems you are facing and *quantify* the baseline transportation conditions.

(2) Establish goals for your TDM program and define the severity of your problem.

(3) Define the market segment(s) you expect to affect with your program.

(4) Quantify and articulate the program options that will allow you to achieve your goal.

(5) Consider the legal and or institutional mechanisms you would need to overcome the barriers associated with your preferred program.

(6) Build support for the best program.

(7) Make whatever legal/institutional changes are necessary to implement the chosen program.

(8) Monitor and evaluate your results, and be prepared to make mid-course corrections.

The nature and importance of each of these steps is described below, both for public and private-based interests.

3.5.4 Identify Problems and Define Baseline

The first thing you must determine is whether you have a real and present problem, one that is compelling you to act.

If you are a government entity, you have a problem if:

- You have legitimate traffic congestion, caused by an inability of current facilities to accommodate travel demand at an acceptable level of service;
- Traffic congestion will occur in the near future, as development or through traffic rapidly increase and you are unable for environmental or other reasons to build new physical capacity; or
- A legal requirement, such as the Clean Air Act, that mandates a certain reduction in vehicle travel is imposed on you.

If you are a private entity, you have a problem if:

- You need to reduce vehicle trips to an existing site to allow efficient company operation;

- A legal requirement mandates that you reduce vehicle trip generation at an existing site; or

- You are required to reduce vehicle trip generation at an existing or new site in order to gain permission to expand at the existing or new site.

Each of these problems can be defined by measures that gauge the severity of the problem. For the government entity, whose concern is generally focused at an area-wide or corridor level, severity is measured through the physical relationship between supply and demand. Frequently used measures and indications of severity include:

- Volume-to-Capacity (V/C) ratios on particular facilities, which reflect the traffic the facilities are carrying (or will be carrying) relative to their design capacity. The closer this ratio is to the number 1.0 (volume equal to capacity), the poorer the level of service and the worse the congestion.

- Level of service at key intersections, as measured by the number of cycles (time) to clear the intersection, critical lane movements (vehicle volume), and queuing and delay. The longer the delays and heavier the volume of traffic, the more serious the problem.

- Measures of travel efficiency such as average vehicle occupancy (AVO) rates or modal split (percentage of travelers arriving by single-occupant vehicle, carpool, vanpool, transit, and other modes), which reflect the efficiency with which vehicles are transporting people. The closer AVO is to 1.0 (one person per vehicle) and the higher the percentage of single-occupant vehicles in the mode split, the greater the problem (or potential problem).

Private entities generally have a more narrow focus, being concerned only with vehicle trip management. The most appropriate measures are:

- Measures of travel efficiency for travelers arriving at a work site (modal split or average vehicle occupancy rate); and

- Degree of demand peaking at the site (distribution of arrivals and departures by time).

There are conventional methods to develop these measures of activity and severity, that may involve either traffic engineering measurements or various types of market research. Some tools are more precise and detailed than others. Your choice will depend on the importance you will assign to the measure. Appropriate techniques are laid out in the respective Guidance Manuals.

3.5.5 Establish Goals and Define Severity of the Problem

The second step of the process is to ascertain how far the measured baseline condition is from the desired or required position, that is the severity of the problem. The *severity* of the problem is determined by measuring the difference between a current (baseline) condition of one or more of the measures and an improved condition or goal for the same measures. The greater the disparity, the more severe the problem. Implicit in this determination is the setting of a goal that will define resolution of the problem. It is important to note, however, that the goal is not a constant. It will differ with different locations, based on the tolerance of travelers to congestion in the area, required engineering standards, the requirements of trip reduction regulations, and other factors specific to the area and population.

If you are a government agency, your assessment of severity and establishment of goals may occur in the following manner:

- Your present or calculated future level of traffic congestion on the highway system equates to a V/C ratio or level of service that violates established or perceived standards for that type of area (urban core versus suburban, for example). The goal then becomes reaching a tolerable V/C ratio or level of service.

- A warrant establishes minimum performance or level of service at all or a certain number of critical intersections. The goal is then set at this level of performance.

- An external requirement, such as the Clean Air Act, sets specific goals for vehicle miles of travel, vehicle trips, average vehicle occupancy rates, or other measures. These measures and targets become the goals.

If you are a private concern, your assessment of severity and establishment of goals probably occurs in one of two ways:

- If you are subject to a trip reduction regulation, your goal is a maximum number of vehicle trips which you may generate at your site, a minimum average vehicle occupancy, or minimum or maximum level of some other measure of travel to your site.

- If you are implementing a TDM program for reasons other than compliance with a regulation, your goal may be to either reduce costs associated with employees transportation, or reduce employee access problems.

These two -- steps quantifying the problem and setting the goal -- are among the most important in determining how you will proceed with TDM. If this analysis shows a very slight departure between current/projected conditions and the goal, then little action is necessary. On the other hand, a significant discrepancy between current or projected conditions and the goal signals a need to be very serious and methodical in the program review steps that lie ahead. This is particularly so if there are strong legal penalties for not achieving the goal, such as occurs under the Clean Air Act where there are impending highway funding sanctions.

3.5.6 Define Markets

Before you can take reasonable steps toward developing solutions to your transportation problem, you must first take time to characterize and better understand the travel markets that are contributing to your problem, and to decide which you are willing or able to affect.

If you are a government agency, you need to ask the following questions:

- At what time of the day or week does your problem occur: primarily during the weekday peak period, associated with high percentages of commuter traffic, or at other times of the day such as mid-day, weekend travel, or special events?
- To what extent is your problem caused by travelers who are beginning or ending their trips within your study/impact area, versus travelers who are simply "passing through" the area?
- What are current travel patterns, in terms of geographic patterns, trip lengths, and modal split/AVO?
- If you are considering actions directed at particular segments of the business community, you might also want to know:
  - The distribution of employment by type of business and size of employer; or
  - The sizes of the employment base that is now in place and the size of the employment base projected to be in place by some future planning horizon year.

If you are a private group, the issues which should concern you are:

- The current modal use patterns of your employees;

- The current time of arrival and departure of your employees;
- The trip length and travel time characteristics of your employees;
- The proportion of employees who now have mass transportation options;
- The portion of your employees who have special constraints which affect their time or method of travel, such as mid-day travel requirements, dependent care responsibilities, or high schedule variability (noting that many of these situations can still be served with alternatives given proper planning).

This basic information is vital in starting your program planning. It tells you:

- How large the market is you *need* to affect;
- The portion of the market you *can* affect;
- The extent to which different strategies are necessary;
- Special market characteristics you need to take into consideration when developing alternatives.

You will find much more specific guidance on performing this market analysis in the special Guidance Manual, *Market Research and Evaluation*. Two other manuals, *Employer-Based TDM Programs* and *Government-Based TDM Programs* also offer guidance on market analysis.

3.5.7 Explore Solution Alternatives

Only after you fully understand the scale and nature of the transportation problem can you begin to explore solutions. It is important to emphasize that there is no single "right" TDM solution. Rather, there will be a number of alternatives that reflect very different social, political, economic, and environmental tradeoffs. The appropriate solution is the packaging of actions that best satisfies immediate local needs, establishes the means for addressing future problems, and can gather the greatest support toward implementation.

Although this document deals primarily with TDM solutions, remember that transportation management is a melding of *all* the intelligent options that are at our disposal. The principal elements are:

- Infrastructure management;

- Land use management; and

- Travel demand management.

If you are a government agency, then realistically each of these elements represents an option as part of an overall management plan, although it should be obvious that the infrastructure and the land use options will require much longer lead times to be effective than the demand management techniques. If you are a private entity, under most circumstances travel demand management is your most reasonable option, though there are opportunities for private groups to contribute to the planning, financing, construction and management of infrastructure and land use measures.

The Employer and Government-Based Program Guidance Manuals lay out many of these steps in procedural detail. This section points out only the major considerations and steps that would go into such an analysis.

If you are a government agency:

(1) Assess the severity of your problem and determine the impact you need to accomplish. This will usually translate into a certain number of vehicle trips or VMT that must be reduced and or additional capacity that must be provided to achieve a satisfactory level of service.

(2) If you are bound by an air quality requirement, you may be constrained from considering capacity expansion as all or part of the solution. In that case, all or virtually all of the solution will have to come from demand modification.

(3) Generally, even though there may be an existing problem, you will be trying to solve problems that will occur over some time horizon, say five to 15 years into the future. Therefore, evaluate the effects of projected growth and development, as well as the effects of planned new infrastructure, on traffic and/or/air quality. Obviously, to the extent that we direct those land use and infrastructure patterns, we will affect travel and traffic conditions in the future system.

(4) Using conventional planning procedures and tools, experiment with alternative land use management patterns and different infrastructure investment programs. In effect, perform a sensitivity test to ascertain what would happen if these major variables were manipulated. For example, land use patterns that involve greater concentration of activity and better integration among residence, employment, and services theoretically lessen the demand for vehicular travel.

(5) Even if you feel it is unrealistic to consider changing land use arrangements, you will want to analyze the impacts of different scenarios in the area's infrastructure investment plans. Funding, environmental or programming issues may place highway plans at different levels of certainty. It is possible to "model" the impact that different programs would have on system travel characteristics if they were built. In effect, you can generate an array of possible future outcomes that reflect the inclusion or exclusion of these potential investments.

(6) After determining the outcomes of different land use and highway investment opportunities, assess any "residual" problems remaining in each scenario. *This is the effective point to introduce the consideration of TDM measures to complete the solution of the problem.* As with the land use and or infrastructure analysis, numerous combinations of TDM measures will produce similar results. You will want to identify and articulate the full range of options that are practical and available.

Information sources and tools are available to facilitate this TDM analysis. The Employer and Government Guidance Manuals present look-up tables that indicate the trip reduction potential of different groups of TDM actions. For more advanced analysis, a special computer software program is available to identify and evaluate TDM program options in much more detail. The Guidance Manuals provide additional information on the nature and availability of this model.

If you are a private entity, your analysis will be much simpler. Generally, you can assume that land use and highway changes are outside your control, leaving as your major option managing the demand for travel through TDM. However, you will still want to examine the range of potential options available to you.

(1) Assess your initial conditions and define your goal (often a legislated requirement). The difference in these two conditions is how much your program must accomplish.

(2) As with the government-based procedure, review the "menu" of management options available to you, using existing information and tools. The Employer-Based TDM Program Guidance Manual provides look-up tables and worksheets that will help you perform an initial analysis. The manual will also introduce you to a computer model that could assist you in performing a more complete analysis.

(3) Generate as many program options as you practically can, so that you have the basis to begin to decide which approach is best for you.

3.5.8 Evaluate Options

After generating a comprehensive list of options, you are now ready to evaluate and prioritize those options. What this amounts to, in effect, is a *tradeoff analysis.* Whereas the previous analysis may have been largely technical, performed by planners, this next step is broader. A host of factors must be considered when reviewing and ranking the list of options, including:

- Prevailing legal requirements, e.g., Clean Air or Congestion Management;
- Cost effectiveness;
- Time frame for impacts to be realized;
- External funding or programming incentives;
- Stability of solution (will it hold up, be "lasting"); and
- Public and political support and backing.

The dominate factors in this tradeoff analysis and ranking generally are the ***barriers***, discussed earlier. Particularly when it comes to TDM, tradeoff considerations will quickly conclude that certain actions, most notably those involving economic measures, will be "impossible to implement", and hence should not be seriously considered. *This is the major trap in TDM implementation. The primary lesson to learn from this presentation is not to dismiss options out of hand simply because conventional wisdom or experience has not successfully dealt with it. On the contrary, if you review TDM options relative to the alternatives you will likely find that (1) they are much more cost effective than most supply-side options, and (2) they deliver quick (and lasting) relief, benefits for which you are willing to fight.*

In a TDM analysis, therefore, it is important first to review objectively the potential impacts of a TDM program and compare the impacts to those of other alternatives. Then, if you feel the impacts are worth achieving, explore creative methods with which you can overcome traditional barriers. The next section describes several possible implementation options.

3.5.9 Implementation Options

There are numerous ways to implement a TDM program, once it is decided that TDM measures are needed and what specific types of measures are to be incorporated in the program. These implementation mechanisms are discussed in some detail in three Guidance Manuals, the previously mentioned **Employer-Based TDM Programs and**

Government-Based TDM Programs, and a third manual, **Legal and Institutional Implementation Mechanisms**. This section addresses them only in a strategic context.

For government agencies, two primary types of implementation mechanisms are possible: legal/regulatory, and institutional/economic.

Legal/Regulatory:

Government entities most commonly initiate TDM actions through the passage of laws or regulations. These may emanate from any level of government, federal, state, or local.

- **Local Zoning/Development Review:** Local governments have a time honored tradition of seeking concessions from developers or land owners at the time of granting zoning or development approvals. For transportation, they can seek as concessions either fees to help mitigate traffic impacts, or commitments from the developer/employer to implement trip reduction measures at the new site. The shortcoming of this approach is that it generally only applies to new development situations, and sidesteps what may be serious existing transportation problems.

- **Trip Reduction Ordinance:** Increasingly, high-growth or traffic prone jurisdictions are enacting local ordinances that restrict the vehicle trip generation of certain types of developments. These ordinances vary in their application (all versus just new employment), the level of specificity/prescriptiveness in the requirement, the method of demonstrating performance, and the ability of the jurisdiction to enforce the requirement.

- **Air Pollution Regulations:** Requiring trip reduction as a means to achieving acceptable air quality is becoming an increasingly important motivation. In the late 1980s the South Coast Air Quality Management District enacted Regulation XV, a regulation that places substantial trip reduction requirements on employers in the Los Angeles metropolitan area. As of 1990, the new Clean Air Act Amendments extended similar requirements nationwide to areas with chronic air quality problems. The CAA Amendments will impose strict planning and compliance rules on states. States that do not reduce vehicle travel and emissions will be penalized by withholding of highway funding. The states will be obliged to enact enabling legislation to transmit these requirements to the local areas and ensure compliance. In severe ozone non-attainment areas, Employer Trip Reduction Programs will require employers of 100 or more to take steps to improve their average vehicle occupancy by 25 percent over ambient levels.

Institutional/Economic:

Another category of actions, institutional and economic, although not used extensively by governments to date, is being discussed with increasing frequency.

- **Funding/Programming Incentives:** Governments stand to save significant resources where they can avoid costly capital improvements, particularly in heavily developed urban areas. Certain states, like Pennsylvania and Florida, are now considering highway programming and funding measures that would reward areas that take steps to concentrate their growth and limit their trip generation through TDM.

- **Employer Incentives:** Some states "New Jersey for example" are considering legislation that would provide tax credits to employers who offer incentives to employees who use higher-occupancy modes of travel.

One consideration for employers and developers in TDM implementation is whether to attempt to accomplish the trip reduction requirement alone, or as part of a collective process. Two primary collective mechanisms are now in use or being considered:

- **Transportation Management Associations (TMAs):** TMAs are organizations of developers and or employers in a particular subarea or impact zone, working together to solve transportation problems. The staff of the TMA helps educate members in the problems and requirements of the situation, may perform necessary market research, and helps articulate appropriate alternatives. The TMA frequently interacts with the public sector (governments and transportation agencies) to fashion cooperative courses of action. The TMA's strength is in its ability to share resources, information, and influence to develop and support common solutions. Two potential shortcomings of TMAs, however, are that they typically are voluntary organizations, with limited resources, and its decisions are not binding on the members.

- **Transportation Management Districts (TMDs):** A TMD is similar to a TMA, but is a potentially stronger implementation vehicle. Patterned after a benefit assessment district, a TMD is formed (often by legislation) to support the mobility and viability of its members, who are declared to be beneficiaries in various degrees of the services provided. Service fees are levied on these beneficiaries and are used for a variety of related purposes, from financing infrastructure projects to providing TDM services and incentives. TMD membership can be mandatory, placing greater impact behind the adopted measures, and giving the organization greater respectability and clout when dealing with the public sector.

These mechanisms can be effective vehicles to implement virtually any TDM program and to overcome the key barriers to implementation.

3.5.10 Monitoring and Evaluation

As stated earlier, a TDM program is not a static or one-time prescription. External events, such as economic conditions, technology and other factors, will affect development, lifestyle, investment, and policy positions. As a result, a comprehensive transportation management program that seems optimal today may not fit the area's needs in the future. In like manner, a chosen program may not be implemented as it was originally planned, or achieve quite the effect that had been projected. In these cases, alternative or corrective action may be necessary.

Because a TDM program is a dynamic activity, it is necessary to design into the implementation a continuing program of monitoring, enforcement and evaluation. Guidance on how to perform these procedures is set forth in the **Guidance Manual on Market Research and Evaluation.**

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