To the Graduate Council:

I am submitting herewith a dissertation written by Douglas Wayne Wiersig entitled "Planning Guidelines For Selecting Ridesharing Strategies in Small and Medium Sized Urban Areas." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Civil Engineering.

Frederick J. Wegmann, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

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PLANNING GUIDELINES FOR SELECTING RIDESHARING STRATEGIES IN SMALL AND MEDIUM SIZED URBAN AREAS

A Dissertation

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Doctor of Philosophy

Degree

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ABSTRACT

This research describes a set of planning guidelines for evaluating and selecting alternative ridesharing strategies in small and medium sized urban areas. The guidelines enable a detailed step by step analysis that begins by assessing the role of ridesharing in the study area and proceeds through market identification, alternative strategy identification, strategy evaluation, and final program evaluation. The guidelines specifically address the topics of strategy evaluation and selection and do not deal with detailed implementation steps or issues. For each step in the evaluation process a list and discussion of critical evaluation factors is presented so that each strategy is systematically evaluated and assessed relative to surrounding market conditions.

Specific elements which are presented as part of the guidelines include:

- o A comprehensive and full description of eight major alternative ridesharing strategies and documentation of operational experiences;
- o A bibliography index of selected references for each alternative ridesharing strategy;
- o An investigation of individual and household attitudes and behaviors related to ridesharing;
- o A set of supply models that estimate the number of commuters needed to participate in ridesharing to achieve given levels of reduction in vehicle miles of travel, energy consumption, and parking demand; and

- An assessment of existing methodologies for estimating expected ridesharing demand as a result of transportation policy changes.

In addition to these elements, an investigation was undertaken to develop a quick response sketch planning methodology for estimating ridesharing demand. The analysis attempted to develop a mode split model utilizing multiple linear regression techniques and characteristics of the trip and trip maker. After analysis, the methodology did not accurately distinguish between those commuters who rideshare and drive alone and indicated that the decision to rideshare is based on a combination of travel related and attitudinal factors. As a result of this failure, three quick response techniques are suggested from existing methodologies: (1) the Department of Energy's manual mode choice method, (2) administration of local surveys to identified market segments, and (3) examination of previous strategy applications in other communities.

Further conclusions reached through this research were: (1) to ensure selection of the most effective ridesharing strategies, a systematic analysis of alternatives should be undertaken; (2) to assess whether ridesharing is realistically capable of achieving desired reduction levels in VMT and energy usage supply estimates of ridesharing participation levels should be undertaken to determine the number of commuters that must participate in new or expanded ridesharing arrangements, and; (3) attitudes of ridesharers and nonridesharers toward ridesharing should be investigated so they can be utilized in identifying ridesharing strategies that address those issues.

Through use of the evaluation procedure presented in this research and accompanying support materials, a quick and comprehensive analysis of ridesharing options can be undertaken to determine those strategies with the greatest potential for increasing ridesharing rates and reducing VMT and energy usage.

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CHAPTER I

INTRODUCTION

Transportation activities have changed significantly in recent years with emphasis shifting from major highway construction and long-range master planning, to a more diverse set of issues and concern for achieving a set of short-term objectives. A fundamental strategy of short-term objectives is to encourage more efficient use of existing highway facilities through increased vehicle occupancies. Ridesharing offers the chance to extend the utilization of existing transportation systems in ways that increase their efficiency while reducing the need for additional vehicles and roadway capacity.

In the search for solutions to the overwhelming problems of air pollution, traffic congestion, energy shortages, and the effect of each of these on the health and productivity of the consumer, a number of alternative solutions have been considered. Solutions range from huge capital intensive rapid rail systems to local ordinance changes that restrict parking in congested areas. Ridesharing appears high on the list of promising alternative solutions. It is relatively inexpensive, flexible, almost immediately available, and does not threaten major dislocation to either the economy or lifestyle of the population.

Given this renewed interest toward ridesharing, transportation planners must have a thorough understanding of each alternative ridesharing strategy and be capable of identifying market segments that are best suited for successful implementation of a comprehensive ridesharing program. Ridesharing programs which have been found to be most

effective in increasing vehicle occupancies are generally the result of matching appropriate strategies and market segments together. Strategies can take the form of incentives that directly induce commuters to share rides by offering specific enticements or disincentives that indirectly encourage ridesharing by imposing penalties for driving along. Because of the range of diversity in these strategies and the need for quick reaction in the time of crisis, planners are confronted with the difficult task of evaluating option under limited time frames and financial resources.

Objectives

In order to define the role of ridesharing as an action to increase the efficiency of existing transportation facilities, a well defined set of planning and evaluation guidelines are necessary. Of particular concern is small and medium sized urban areas which frequently lack the planning resources to undertake extensive planning investigations. The purpose of this research is to develop a step by step procedure for allowing planners of small and medium sized areas to evaluate and select ridesharing strategies. The guidelines enable a detailed step by step analysis that begins by assessing the role of ridesharing in the study area and proceeds through market identification, alternative strategy identification, strategy evaluation, and final program selection. The guidelines are directed to issues in small and medium sized urban communities, but are also applicable to many situations in large urban areas. The guidelines specifically address the topics of strategy evaluation and selection and do not deal with detailed implementation

steps or issues. Throughout the text and specifically in Chapter 3, references have been provided for those interested in pursuing detailed implementation informaton.

Specific elements which are presented as part of the guidelines include:

- o A comprehensive list and full description of each alternative strategy and documentation of operation experiences;
- o An investigation of individual and household attitudes and behaviors related to ridesharing;
- o A set of supply models that estimate the number of commuters needed to participate in ridesharing to achieve given levels of reduction in vehicle miles of travel, energy consumption, and parking demand; and
- o An assessment of existing methodologies for estimating expected ridesharing demand as a result of transportation policy changes.

Through use of these guidelines and accompanying documentation, planners will have a reference guide to identify strategies most applicable to their community and determine those with the greatest potential for increasing ridesharing rates and reducing VMT and energy usage.

CHAPTER II

GUIDELINES FOR EVALUATING RIDESHARING OPTIONS

In the planning and selection of transportation programs planners are increasingly interested in evaluation techniques which enable a concise straight forward assessment of alternative ridesharing programs. To help fill this need, a set of planning guidelines has been developed which presents a step by step procedure for evaluating and selecting ridesharing strategies. These guidelines begin by assessing the role of ridesharing in the study area and proceeds through market identification and strategy evaluation. The guidelines are directed at conditions in small and medium sized urban communities but are also applicable to many situations in large urban areas. Figure 2.1 presents a flow chart of the guidelines and defines the seven steps undertaken in evaluating and selecting ridesharing strategies.

The initial step of determining goals and objectives is carried out in conjunction with the overall transportation planning process where transportation issues and problems have been identified. If a community has not developed a set of goals and objectives, work by Grecco and Dames (1975) presents a procedure for developing goals and objectives as well as a sample set that can be used as a start point. The purpose of this step is to determine if ridesharing strategies address these issues and are capable of meeting desired goals and objectives. In formulating a comprehensive transportation program, alternative modes and programs are combined in an effort to develop a

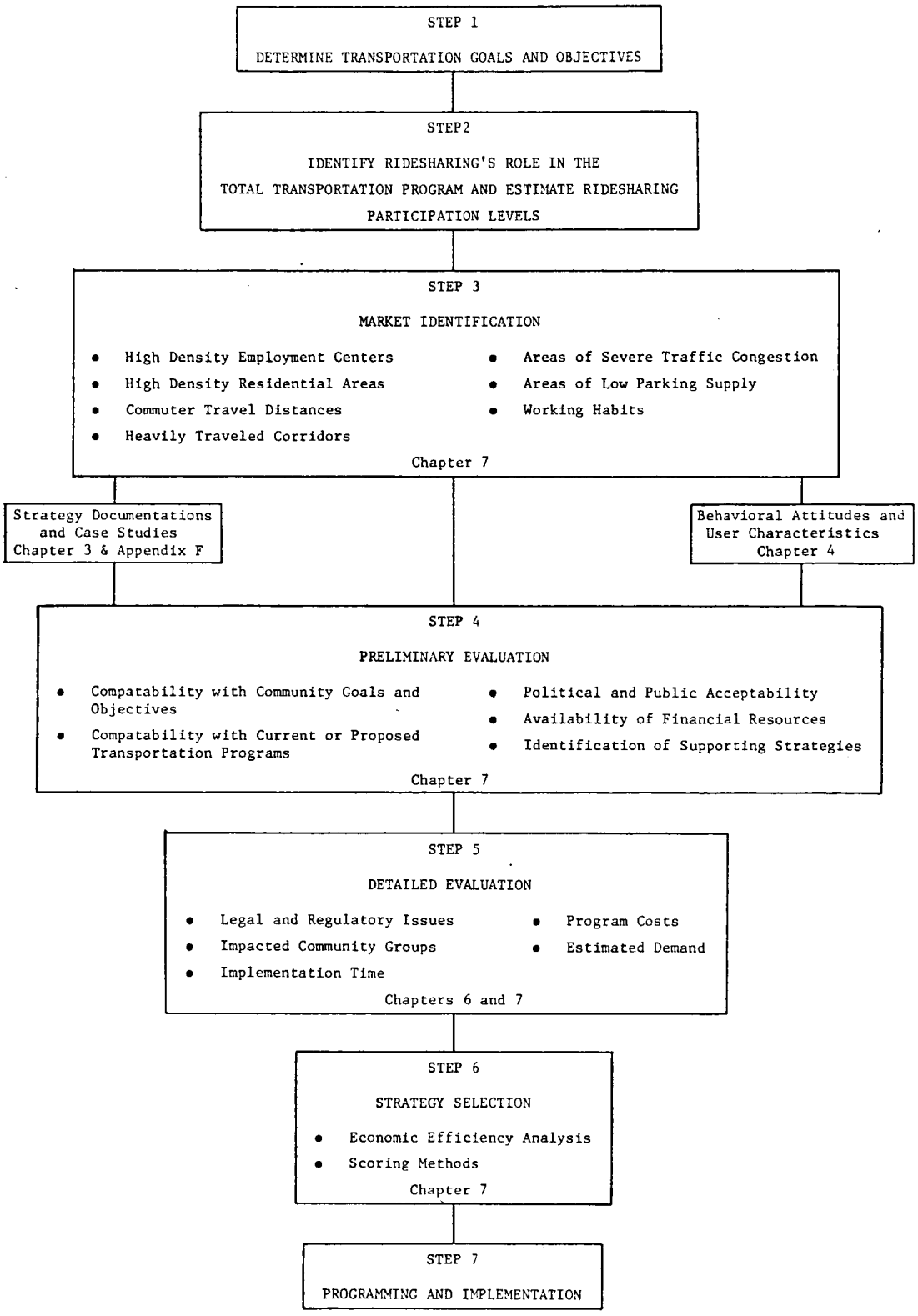


FIGURE 2.1 PLANNING GUIDELINES FOR RIDESHARING STRATEGY EVALUATION AND SELECTION

balanced system. Each mode and program is directed at its appropriate market segment and expected to contribute a specified proportion in achieving overall goals such as energy or air pollution reductions. If a certain program fails to attain its anticipated proportion, overall goals may not be reached unless adjustments can be made in other programs to cover the additional share.

Step 2 attempts to identify ridesharing's role in meeting overall community goals by determining necessary participation levels. If ridesharing is expected to contribute a specified portion in community wide energy reductions, it is essential to know whether these levels can realistically be obtained. Determining necessary participation levels is also a key factor in the level of intensity and priority given to ridesharing. If the community or individual firm has elected to undertake a ridesharing program as their major means of reducing VMT and energy usage, determining participation levels identifies the degree of effort necessary to reach these desired reduction levels. Participation levels can be determined through the supply models developed in Chapter V and comparing them to estimated demand figures derived in Step 5 of the guidelines enables a quick assessment of the ability to meet the supply values and allows estimation of resulting program costs. Based on these participation levels and the resulting degree of effort, a decision can be made to proceed with the program at the specified level of intensity or adjust the reduction levels to coincide with acceptable intensity and funding levels.

Step 3 is directed at identifying market segments within the study area that are capable of supporting alternative ridesharing strategies.

Market segments in this context can be groups of commuters with similar travel or socioeconomic characteristics or areas within the community that possess characteristics necessary for application of particular strategies. A checklist of seven factors has been identified for use in determining applicable market segments and strategies. In addition to these seven factors, resources from strategy documentations and behavioral attitudes of Chapters III and IV respectively are utilized in identifying potential markets. Familiarity with strategy characteristics and behavioral attitudes of commuters toward ridesharing are essential elements in identifying potential markets and applicable strategies. Through identification of market segments, potential strategies are then selected which have similar market characteristics. For example, if a heavily traveled corridor with a large volume of common origins and destinations exists, vanpooling and preferential lanes may be applicable strategies.

The next phase in the selection process, Step 4, is to assess these potential strategies in a two phase process of preliminary and detailed evaluation. Preliminary or first cut evaluation is oriented toward narrowing the range of strategies to be evaluated in detail to those strategies best suited to the study area and eliminate analysis of least applicable strategies. Each strategy is assessed against five preliminary evaluation factors which address issues of compatibility with goals, objectives, and other transportation programs; political and public acceptability; availability of financial resources; and identification of supporting strategies. Determining if a strategy is

politically acceptable or availability of funding early in the selection process streamlines the evaluation and avoids the costly and time consuming task of analyzing unacceptable strategies.

The fifth step in strategy evaluation is a detailed evaluation of strategy costs, benefits, impacts, and institutional issues. This detailed evaluation enables a close examination of expected impacts and institutional issues which may arise, and identifies quantitative and qualitative measures of cost and benefits which can be expected to occur. A list of five evaluation measures are considered in this detailed analysis phase with results being the primary basis for final program selection.

The final step in strategy selection (Step 7) is to combine strategies into workable programs and determine the most efficient set of strategies. In this selection phase, results from the previous two evaluation phases are combined to rate the effectiveness of various combinations of strategies. Analysis procedures such as economic efficiency analysis (benefit cost, rate of return methods) and scoring methods can be utilized in combination or individually to compare program effectiveness (Cohen, 1978; DeGarmo, 1979).

Through following this evaluation framework and utilizing the various resource procedures and assessment factors, a comprehensive analysis of ridesharing options can be performed. Material presented in the remaining chapters focuses on the elements comprising the evaluation procedure, Steps 2 thru 5 and is intended as an additional resource when evaluating strategies.

Chapter III provides a documentation of eight major categories of ridesharing strategies which can be used throughout the evaluation process as a reference source. Each strategy is discussed in a standard format comprising a brief description, market identification, implementation, institutional/ legal barriers, and public acceptability. In addition to this documentation, Appendix A contains a bibliography index of selected references for each strategy and Appendix F presents a review of several operational experiences for each strategy.

Chapter IV presents a discussion of ridesharing attitudes and user characteristics which are useful in gaining a general understanding of ridesharing and why commuters decide to pool. This information is used primarily in Steps 3 and 4 of market identification and preliminary evaluation. It is important to be sensitive to issues that nonridesharers might view as reasons for ridesharing such as parking problems or high insurance premiums so that candidate strategies can be matched to these issues which inturn should influence commuters to rideshare.

Chapter V presents a set of supply models that are utilized in assessing ridesharing's role in the total transportation program. These models are used in conjunction with Step 2 of the planning guidelines and identify the number of commuters needed to carpool and vanpool to achieve desired reduction levels in VMT, energy, and parking supply. These participation levels are also used in assessing the needed size of market segments, especially when isolated smaller applications are being considered.

Chapter VI presents an analysis of various methods which estimate expected demand for ridesharing as a result of ridesharing incentives

and disincentives along with techniques that can identify the size of groups of commuters with similar travel characteristics. These procedures which are utilized in detailed evaluation section, Step 5 enable a quick inexpensive analysis of anticipated demand to be undertaken.

Chapter VII presents a discussion of the evaluation factors comprising the market identification and preliminary and detailed evaluation phases of the planning guidelines, Steps 3 thru 5. An analysis of the important considerations and impacts for each factor is presented along with summary tables that can be used as a reference guide in assessing strategies.

Through following the evaluation procedure outlined in this chapter and utilizing the specific support materials contained in Chapters III thru VII, a quick and comprehensive analysis of ridesharing options can be undertaken. The accompanying support materials are organized so that planners can easily access those sections of interest and locate desired information.

CHAPTER III

RIDESHARING STRATEGY DOCUMENTATION

In assessing the role of alternative ridesharing strategies and determining their applicability to a particular study area, a basic understanding of the strategy is essential. The material presented in this chapter contains a concise documentation of eight ridesharing strategies and is intended for use as a quick reference guide. The major strategies covered in this review include:

Carpool Matching and Promotion Programs;

Vanpool Programs;

Employer Financial Incentives for Carpools and Vanpools;

Preferential Traffic Control;

Park and Ride Facilities;

Parking Management Techniques;

Facility or Area Tolls; and

Alternative Work Schedules.

To facilitate use as a reference document, each strategy is described using a common format composed of the following five subsections.

Description - Definition of the strategy;

Market Identification - Identify market segments most applicable for implementation;

Implementation - Promotional campaigns; start up time required for full-scale implementation; technical difficulty and uncertainty associated with implementation; and program costs and benefits;

Institutional/Legal Barriers - Institutional arrangements or legal requirements necessary for implementation;

Public Acceptability - Identify expected support that could be received from commuters and the general public;

In addition to this documentation, Appendix A contains a bibliography index of selected references for each strategy and Appendix F presents a review of several operational experiences for each strategy. The remainder of this chapter is devoted to a discussion of each strategy.

Carpool Matching and Promotion Programs

Description. Carpool matching programs encompass a wide variety of techniques that locate people with similar work related travel characteristics who wish to form or join a carpool. Programs range from those encompassing an entire community (area wide), an activity center or a specific single employer.

Community wide programs operated by local governments or non-profit corporations provide services to an entire area and primarily work through employers in collecting the majority of employee travel patterns. Specific employer based programs on the other hand are

usually operated exclusively for the use of one employer and generally serve that employer. Matching of employees is achieved through computerized matching routines for area wide and even some larger employer programs with manual locator boards and pin maps used for small employer programs.

In both types of ridesharing programs, public information and advertising has been widely used to increase awareness and create positive attitudes toward carpooling among employees. Typically used techniques include TV, radio and newspaper advertising, billboards, mass mailers, bumper stickers and information booths and displays.

Area wide programs are sponsored through various local organizations and includes agencies such as the chamber of commerce, office of public transportation, traffic engineering department, metropolitan planning organization, transit authority, and private sector (non-profit) governmental partnerships.

Market identification. Areawide carpool matching and promotion tends to be most applicable to medium and large size urban areas rather than small urban areas. The reason being that small urban areas lack large employment concentrations and trip lengths tend to be shorter. In cases where one or two large employers are located in a small urban area, matching programs at these sites may be applicable. Major shifts to carpooling is doubtful on a community wide basis in these small areas without significant increases in gasoline prices or reduced availability. This was the case in many small communities that undertook matching programs immediately following the oil embargo.

In medium and large urban areas, matching assistance is most applicable at sites having large concentrations of employees, such as large individual employers, the central business district, and regional activity centers. Matching services provided to the public at large in these areas are successful only after a sufficient data base has been established, preferrably from large employment centers. If a sufficient data base is not established, individual requests received from the community at large will be matched with too few individuals and the expected formation of new carpoolers will be low.

In medium and large size urban areas where employee concentrations are low or commuting distances short, area wide matching programs may result in low to moderate success. This is primarily due to the large number of employee home and work combinations which result in a low matching rate.

Specific employer programs are most applicable for large employers due to greater matching potential and ability to absorb administrative costs. This is not to say that with proper market characteristics of longer commuting distances and few employee home to work combinations, carpool matching would not be applicable to a small firm. Nationwide there are many isolated examples of small companies whose programs have been very successful.

Implementation. Carpool matching and promotion programs on a community wide basis are relatively inexpensive strategies when compared to other transportation improvements such as highway or street construction. Based on 26 ongoing projects, annual operating costs

range from $20,000 - $660,000 with an average of $140,000 per per project (Wagner, 1978). On a per capita basis the costs range from 2¢ to 33¢ with an average of 13¢. As expected per capita costs decrease with population size from an average of 20¢ for areas less than 500,000 population to 5¢ for areas with greater than 2.5 million population. Major program expenses are for staff salaries with computer services, printing, mailing, advertising and other miscellaneous items comprising the remainder.

Funding for area wide projects is primarily through the Emergency Highway Energy Conservation Act of January 1974 which authorizes the use of Federal Aid Highway Funds (both primary or urban system Funds) to finance 75 percent of the cost of carpool projects. Federal funding is also available through the Department of Energy's Energy Policy and Conservation Act which is administered through each state's energy office.

Carpooling programs are immediate action strategies and require little start up time. In area wide programs, match lists can be distributed to employees within 6 to 12 months from the program start while single employer programs require 3 to 6 months. For an aggressive area wide program at least 1 to 1.5 years is required to adequately canvass most employers in the area.

To effectively utilize project resources and contact large concentrations of employees in the shortest time period possible, it is most efficient to concentrate promotional and survey efforts with major employers rather than a mass public wide campaign. However, public campaigns are useful as an educational device to increase ridesharing

awareness. Serious employer commitment on a continuing basis is necessary for an effective program due to the ease in reaching employees and the later need of updating records when travel patterns change. When a sufficient data base has been established, matching services for the public at large can be given more emphasis and consequently result in a greater matching rate.

An important consideration in the initial planning of a carpool program is determining the local organization which will administer the program. Candidate sponsors could be city government, regional government, a local or regional transportation authority or a private non-profit corporation. The program should be placed with the organization that has the largest geographical area and political jurisdiction to insure that services can be provided to the entire commuter shed without political overtones and conflicts with local funding sources. The program should be capable of providing information and coordinating services with other transportation services such as the transit system, taxis, vanpools, social service suppliers, and other transportation suppliers without extensive conflicts among suppliers. Finally the program should be located in the organization where it has the greatest probability for adequate and continuing funding. Even though no project can be guaranteed continued funding, it is best to avoid organizations where funding battles seem evident, since this task occupies resources that could otherwise be used in promoting the program and inturn lowers public creditability.

To date there are few examples of successful area wide carpool programs in terms of significantly increasing ridesharing mode split.

A recent evaluation of FHWA carpool demonstration projects reported that the better programs achieved one or two percent increases in carpool's market share of total areawide trips. This resulted in little impact in community wide VMT and pollution reductions (Wagner, 1978). Even though many projects were inadequately staffed and funded, it seems doubtful that additional resources would have produced better results given the general availability of gasoline and current attitudes toward driving alone.

For carpooling programs to increase their effectiveness they must be operated in a strong and aggressive manner and be accompanied with supporting strategies. The chance of an individual switching to a carpool are enhanced if incentives such as reduced travel time or financial disincentives which penalizes the driver alone commuter are involved. To implement a program with current gasoline prices and availability without some type of accompanying initiatives, one can only expect to observe modest success.

Institutional/legal barriers.

- Regulation is not a problem with carpools as seen from the point of the Public Utilities Commission or similar body. There has not been any reported attempts to impose regulations such as common carrier status on carpools.
- Confidentiality or security of employee records has presented some problems in many programs. Many employers have been reluctant to engage in matching services

for fear of outside interference and disruption of internal operations.

- Carpoolers and insurance companies are becomming increasingly aware of the attention toward claims against the liability policy of carpool drivers. Claims could be made by carpool passengers (usually all heads of households) in the event of an accident. This concern has lead many individuals to avoid carpooling due to the increase in insurance premiums for additional bodily injury coverage and the possibility of a large claim being made against them. Even with this increased liability/exposure on the driver, insurers have tended to classify all carpools the same (shared-vehicle) and not increase rates for those driving all the time. In fact, many insurers grant a carpool discount of about 10 to 15 percent to those who do not drive their own vehicle to work daily.
- One of the most significant issues which a transportation improvement relying on federal money may have is competition with existing public transportation systems and Section 13(C) regulations of the Urban Mass Transit Assistance Act. Section 13(C) states that federal funds cannot be used to promote carpooling where significant number of riders would be drawn from an existing public transportation system. To date existing carpool programs

have not diverted a significant number of individuals from transit, primarily due to the fact that no program has been able to establish a significant number of new carpools. This issue does warrant some consideration if a program is targeted for the CBD or a heavily traveled corridor with substantial transit service. From evaluations conducted in San Francisco and Washington, D.C., it was found that 33 and 25 percent of new carpoolers respectively were diverted from transit, thus indicating the potential for competition, at least in larger areas with, transit. In most communities however, this potential conflict should be minimal since the percent of commuters using transit is low and their trip characteristics are somewhat different than those of carpoolers.

- Some employers are concerned that carpool programs and incentives could be construed as coercion and increase their chances of being liable in case of carpool accidents. This is especially true if incentives become more extensive and attractive.
- Various employers are concerned that carpool programs and extensive incentives may become a negotiable item in labor negotiations. This has already been the case in the Tennessee Valley Authoritie's Ridesharing Demonstration Program where express bus and vanpool subsidies were negotiated in the employee labor contract.

Public acceptability. Carpool matching and promotional programs are widely accepted by the general public, community leaders, and public officials as a means of reducing air pollution and traffic congestion and conserving energy. The only drawback is that carpooling is viewed as a good idea for others, and individuals have been reluctant to actually shift into carpools.

Vanpool Programs

Description. Vanpooling is a prearranged commuter transportation mode of ridesharing service in which a van is used to transport employees to and from their work site. The van, which carries from 8 to 15 riders, is driven and maintained by one of the passengers, usually an employee of a vanpool sponsoring firm. Fares for the service usually computed on a monthly basis cover the full capital, operating, and maintenance costs of the van and in some cases administration costs of the program are also included. In most programs drivers are compensated for driving and maintaining the vanpool through incentives such as a free ride to work, retaining fares collected over a specified occupancy level, and availability of the van for personal use during nonworking hours on a cost/mile basis. Vanpools in turn eliminate the cost of providing for paid drivers, purchasing expensive equipment, and maintaining operations.

Vanpool operations are usually grouped into three categories based on vehicle ownership. Vehicle ownership is an important characteristic since in most cases it determines the mode's regulatory status, the extent of liability, and ease of obtaining insurance.

Employer Sponsored Vanpools: This concept is the most widely practiced arrangement of organizing vanpools. Private employers purchase or lease vans and provide the organization and administrative structure. The drivers of the vans are company employees as are usually all passengers. Each employer establishes its own fare structure which enables it to recover program costs or regain any expenses it does not choose to subsidize for its employees.

In this type of vanpool operation, insurance and regulatory issues are not as cumbersome as others since insurance for the vans is usually included under the company's fleet policies and in most states this type of operation is not regulated by the public service commission.

This type of vanpool operation is limited in most cases to larger employers (greater than 500 employees) due to the need for a substantial matching base and to cover the high costs associated with insurance, administration, and van purchase. Employer sponsored programs are currently operating at such firms as 3-M, Minneapolis, MN; TVA, Knoxville, TN; Conoco, Houston, TX; and Prudential Insurance, Newark, NJ.

Third-Party Sponsored Vanpool: In this arrangement, a public or private organization (some for profit and some nonprofit) sponsors a vanpooling operation for the public at large. These third-party operators provide vans, maintenance, insurance, matching services and other organizational services to employers and employees. As in most vanpools the driver receives some incentive for driving and is responsible for recruiting riders and keeping the van operating. Fares are

based on the practical (excluding administration) or full cost of the operation depending on the organization and may or may not include profit for the organization depending on its status. This type of operation is well suited for smaller employers since it requires little employer initiative and riders are not limited to any one employer. Difficulties arise in developing a third-party program due to regulatory constraints on their entry into the transportation market especially where public transportation exists. Third-party operators exist in Los Angeles, CA; Baltimore, MD; and Honolulu, HI.

Individually Owned and Operated Vanpools: This type of vanpool is often regarded as a "large carpool" by regulatory authorities since the van is owned and operated by individual commuters. In this arrangement the van is purchased, maintained and operated by individual commuters rather than being leased from a third-party operator or provided by employers. Drivers are responsible for maintaining ridership on thier own but often receive help from community wide or employer ridesharing matching efforts. By placing ownership with the individual commuter, funds are not needed by the municipality or employer for van acquisition. Major disadvantages are difficulties in establishing a rider base if no ridesharing programs exist, obtaining insurance coverage, and loans for van financing. These problems maybe overcome in the future with the introduction of local community vanpool organizations sponsored by governments which assist drivers in these areas.

Market identification. Vanpooling, due to economic constraints, is generally felt to be attractive for oneway commuting distances

greater than 15 miles. On occasion, riders may have shorter commuting distances but their decision to vanpool is usually based on some other form of incentive such as a cash incentive provided by an employer, preferential treatment for vanpools, or severe driving conditions in winter months. Employer programs have been initiated for a variety of reasons including parking problems, inadequate transit service to the work site, attempt to reduce employee absenteeism and tardiness, increase the supply of available labor source, and improve employee and community relations.

Vanpool formation has more potential and is easier to arrange at large employment centers (greater than 500 employees) preferably involving a single employer. Although experience in Knoxville, Los Angeles, and San Francisco indicates that vans can operate with riders drawn from various employers, the ease of forming and maintaining the pool is much simpler with a single large employer. This is primarily attributed to compatability in work times, closeness of work site (reduced travel time and cost), and being able to easily recruit new riders.

No one particular employer type appears to be attracted to vanpooling by itself. Both employer sponsored and third-party vanpool organizations have been successful with a wide variety of employers. Vanpooling has been found to be acceptable to a wide range of individuals encompassing a variety of occupational classes. The mixing of both males and females representing a broad spectrum of income and occupations in the same van has been received quite favorably in a number of different programs (Wiersig, 1977).

The concept of vanpooling can be marketed directly to commuters without establishing an employer program through area wide promotional efforts and these programs have been successfully implemented by third-party operators in Los Angeles, Honolulu, and Baltimore.

Implementation. Employer based vanpool programs can usually be implemented in a short time such as three to four months, if state regulatory exceptions have previously been obtained in other vanpool programs and insurance is readily available. Initial start up and organizational costs range between $18,000 and $35,000 depending on the size of the program. These costs include only the in initial staff time requirements for organizing the program, capital cost of vans should be added to this amount. It is suggested by most program managers that a pilot program consisting of a few vans first be introduced to determine if vanpooling will be acceptable to employees.

Employers are somewhat hesitant to involve themselves in a company-sponsored vanpool program due to the substantial start up costs and annual administrative costs which run between $250 and $350 per van. This cost is usually absorbed by the company and not included in the fare since it tends to increase fares to the point where individuals will choose not to vanpool. Even large employers are reluctant to commit themselves to these costs, unless there are excruciating circumstances.

In response to this problem, third-party vanpool operators have evolved which promote, manage and organize vanpools for an entire region. Third-party operators may be organized within existing governmental agencies such as the transit operator (Norfolk, VA) or other

public transportation offices, city government (Knoxville, TN) or as a nonprofit corporation as is such the case in Hawaii, Los Angeles, Baltimore, and Minnesota. This type of program requires a longer start up time of approximately six to eight months primarily due to regulatory and insurance barriers which usually must be overcome before service can be provided.

Start up costs are estimated to be a minimum of $60,000 for initial promotion, market research and office setup and does not include salaries for conducting matching services or marketing. Annual ongoing cost for operating and administration of such a program run approximately $40,000 to $60,000 fixed costs for building rent and salaries plus $500 for each vehicle in the fleet. The inclusion of these latter costs in rider fares also tends to raise fares substantially.

Vanpool fares will vary depending on whether vehicles are purchased or leased, the term of the lease and the amount of administrative costs included in fares. Vans purchased at fleet prices result in lower rider rates with long-term leasing (four years) being the next best method of obtaining vans. Short-term leases (two years) result in significantly higher rates compared to the latter two methods.

Third-party operators are attractive to employers, large or small since the employers assume no risk and very minimal costs in administering the program. In areas where third-party operators have begun operation, employers have indicated a preference to switch from their employer based programs to eliminate the need to administer their own program.

Rider fares for third-party operators usually tend to be higher since they include some of the administrative costs of the program which is usually absorbed by the company in employer based programs. In any event, third-party operators have the advantage in that they provide services to smaller companies unable to support their own program.

An important element in organizing a third-party operator is its placement in the existing framework of government. It is important not to restrict the operation geographically by placing political jurisdictions on it through the level of government at which it operates. It should also not have to compete each year for continued funding with other governmental programs. The nonprofit corporations are well suited to bypass these problems while still being eligible for local, state, federal, and private support. However, nonprofit corporations must still receive federal grants through some state or local governmental agency.

Vanpooling is aimed at commuting distances greater than 15 (one-way) miles which limits the magnitude of energy conservation impact that can be achieved since the percentage of these trip lengths is relatively low. A common figure used in estimating the impact of vanpooling is that for each van placed in operation, six vehicles will be removed from the roadway. In the aggregate this value is appropriate, but if analysis is being made for a specific corridor or activity center a closer analysis of employee travel patterns may be necessary. In the Knoxville Vanpool Demonstration Program each van displayed only 4.5 vehicles (Wiersig, 1977). This was attributed to the greater

commuting distance of riders and their diversion from carpools rather than single occupant vehicles. In the Golden Gate Corridor, 45 percent of vanpool riders were diverted from transit resulting in a very low displacement ratio (Farr, 1976). Thus, when estimating the expected results of a vanpool program on VMT reductions and energy conservation, one must look closely at area employment centers, their spatial relationship to employee residences, the type of employees involved, and the extent of transit service provided in the area.

Funding for vanpool programs, if operated by an employer is totally financed by the company except for matching services which may be available through a local area ridesharing program. Funding for employer programs may be obtained from governmental sources for purchase of vans using FHWA Primary or Urban System Funds as long as the purchase price is repaid within a four year period. Abort guarantees of 100 percent may also be applied to employer programs by governmental agencies through these same funds to ensure payment of the vans in cases where programs prove unsuccessful. Third-party operators may obtain funding from a variety of sources, Federal Aid Urban and Primary Funds maybe used for both vanpool planning and van acquisition under the requirement that total purchase price of the van be repaid through user fares within a four year period.

Funding from State Energy Offices is available for vanpooling as well as assistance from State Departments of Transportation. In the case of nonprofit vanpool operators financial assistance maybe received from private sources such as local merchants or companies.

Institutional/legal barriers.

- Employers are concerned that vanpool programs and corresponding incentives may become a bargaining item in labor negotiations. This has already been the case in the Tennessee Valley Authorities Ridesharing Demonstration program where vanpool subsudies were negotiated in the employee labor contract.
- Transit agencies and labor unions may present opposition to vanpooling if they consider it to compete with existing public transportation services. Section 13(C) provisions of the Urban Mass Transit Assistance Act require organized labor approval of any federal aid to paratransit systems. In the four UMTA demonstration vanpool programs, 13(C) agreements were required prior to project implementation. From recent evaluations of vanpool programs in Knoxville and San Francisco it was found that vanpools when placed in direct competition with existing express bus services has tended to divert riders (Wiersig, 1977; Farr, 1976). Even though vanpools were placed to relieve overcrowding on some buses, these examples indicate that some individuals will switch to vanpooling due to decreased travel time and greater mobility.
- Insurance for third-party and private vanpools is still a major obstacle even with the recent Insurance Service's

Office vanpool classification (Davis, 1977). The continued growth in the number of vanpools has caused some insurance underwriters to reclassify vanpools from their special vanpool classification to that of commercial vehicles which has drastically increased premiums. Underwriters are cautious that with the sudden increase in the number of vanpools, the chances of an accident and claims are much greater. To help reduce insurance premiums individuals who vanpool may wish to purchase first party insurance in the form of group health and accident insurance. This form of coverage is relatively inexpensive and provides coverage for medical bills to a specified limit and limited death or disability benefits. This first party insurance provides no liability coverage and can be obtained only on a group rate basis. Consequently, vanpooling would have to be classified as a group, and group definitions for insurance purposes varies with each state.

- In states that have not exempted vanpools from Public Service Commission regulation, vanpools will usually fall under some type of regulation (contract carrier) that restricts their entry into service or operations. This is usually the case in third-party and privately owned vanpools. In all cases, vanpools have been allowed to operate through regulatory changes, but with varying restrictions placed upon the vehicle or the type of services that can be performed. Ideally legislative reform should be implemented to remove all regulatory barriers. In most cases this may

not be politically feasible and a more limited exemption is usually sought.

- Employers are often times wary of implementing a vanpool program or cooperating in developing one for fear of incurring liability to third parties and/or to company employees in the event of an accident. There is fear that employees will be brought under Workman's Compensation during their commuting trips, thus causing an employer's liability exposure to increase and result in increased premiums for Workman's Compensation. To alleviate this concern, state legislatures should clarify the liability situation and clearly state that Worker's Compensation is not to be expanded to cover the time the employee travels to and from work.

Public acceptability. Vanpooling at both the company and third-party level has proven to be acceptable to employers and the general public. Opposition has occurred mostly from local transit operating unions.

Private owner vanpools are also becoming more acceptable and visible with the promotion of vanpool programs. The success in developing private operators in Knoxville was achieved through the sale of public seed vans and in the Golden Gate Demonstration Vanpool Project similar occurrences are reinforcing the concept of private operators.

Employer Financial Incentives for Carpools and Vanpools

Description. Financial incentives which involve the employer can be categorized into two forms. The first are incentives to stimulate an employer to implement a company sponsored vanpool program by providing investment tax credits on the purchase of commuter vans and income tax deductions for operating costs. The second are direct financial incentives by the employer to employees who rideshare (carpool, vanpool or buspool).

To stimulate companies to operate a vanpool program, investment tax credits and accelerated depreciation allowances are available to employers as financial incentives for purchasing commuter vans. Tax deductions are also allowed on the operating cost of company sponsored ridesharing programs. Employers can offer direct or indirect tax free subsidies to employees to encourage the use of carpools, vanpools, or buspools. These incentives have taken a wide variety of forms and include: free or low cost parking to poolers, direct payments to persons ridesharing, subsidization of all or part of the cost of a vanpool program, awarding of prizes to ridesharers through drawings, bonus vacation days for a given number of days carpooling, accrual of credits for savings bond purchases, accrual of bonus deposits into an employee's credit union account, and company-arranged discounts for various kinds of goods and services for which only poolers would be eligible.

Market identification. The implementation of financial subsidies to ridesharers is most applicable to employers who are active in some type of ridesharing program capable of matching commuters. It would

be extremely difficult to establish new ridesharing arrangements if commuters were on their own to find fellow riders. In this case an incentive program would be ineffective in forming new ridesharing arrangements since it would be administered in the most part to those commuters already ridesharing.

Employer subsidies or fringe benefits appear most promosing at sites where commuter parking costs and congestion are high since employers may reduce the cost of a subsidy program by substituting it for parking space costs. The elimination or reduction of high parking costs for ridesharers is also an incentive for commuters to switch modes. These concepts have been applied in companies of varying size, but potential seems best at medium and larger sized companies since the program's effectiveness is linked to the ability of matching commuters and forming new ridesharing arrangements.

In Knoxville, Tennessee the Tennessee Valley Authority demonstrated that an incentive subsidy program was a primary factor in the decision of individuals to vanpool and buspool. When the subsidy program was discontinued during employee contract negotiations, vanpool and buspool ridership dropped by 50 percent and remained at that level for two months until the subsidy was reinstated.

Implementation. At present employers who provide a van or bus to transport their employees to and from work are eligible for the full 10 percent investment tax credit. To be eligible the van or bus must have a three-year useful life; have a seating capacity of at least eight adults, not including the driver; at least one-half the adult seating capacity must be occupied, not including the driver; and at least 80 percent of the mileage must be used for commuting.

Another employer incentive is the ability to deduct from federal income tax, the cost of incentives that the employer provides his/her employees to encourage their use of vanpools (Section 162(a) of the Internal Revenue Code). These deductions can include the administrative cost of a vanpool program as long as they are not included in rider fares. The deduction of incentives provides but only a small recapture of actual expenses and can be considered to have almost no effect in encouraging vanpool programs. If undertaken by a company, vanpooling will most likely be in response to those problems identified earlier such as parking or traffic congestion.

Subsidies to employees who carpool, vanpool or buspool are voluntarily programs undertaken by employers. These approaches toward providing incentives in the form of subsidies is already widely practiced by employers who subsidize transit service for employees by paying a portion of their transit fare or providing free parking and is simply extended to carpools and vanpools. Employers may subsidize directly all or a partial amount of the cost of commuting for those employees carpooling or vanpooling. Subsidies can be based on commuting distance or an equal subsidy for all employees. Administratively, this type of incentive is more applicable to vanpool and buspool riders since the fare for these modes can simply be lowered by the amount of the desired subsidy. Problems arise in the case of carpooling since a greater number of individuals and vehicles are involved and it becomes increasingly difficult to determine who is actually carpooling and entitled to a subsidy without considerable spot checking. From past experiences with preferential parking spaces for carpools it was found that individuals were still driving alone when

they indicated they were carpooling. Their primary motive for signing up as a carpooler was to receive the preferential parking space. It seems doubtful that attitudes have changed and without intensive enforcement or an easy means of observing who is carpooling, abuses in this type of program can be expected to be high.

Application of employer subsidies for vanpoolers and bus riders has proven to be very successful and produced a substantial shift to these modes. The extent of success will depend on existing commuting costs and the availability of parking. The use of subsidies for carpoolers has not been widely used by employers primarily because of implementation problems. A few small employers have provided subsidy programs that have been successful, but with a small firm maintaining control is much easier.

Other incentives which can be offered to employees involve fringe benefits which include items such as monthly prizes to ridesharers, credits for savings bond purchases or credit union shares, bonus vacation days, and discounts for various kinds of goods and services at merchants throughout the area. Incentives of this type are less costly to employers than subsidization, but produce a smaller monetary incentive for employees to shift to ridesharing. Their implementation is relatively simple but the problem still arises in determining who is actually ridesharing and eligible for benefits. Programs of this type have been implemented by various employers but have not resulted in a large shift to ridesharing since employees do not receive a substantial monetary benefit.

Institutional/legal barriers.

- At present parking and employer sponsored vanpools are the only nontaxable fringe benefits an employee can receive. If an employer subsidizes other parts of an employee's commuting cost, the employee would be required to claim these costs as taxable income (1.262-1(b)(5) of the Income Tax Regulations). This in turn will reduce the financial gain of the incentive to an employee and lower their motivation to shift modes.
- Employers and employees are becoming concerned over the problem of equality between ridesharers and nonride-sharers when financial subsidies and fringe benefits are applicable to only ridesharers. This is especially of concern when some employees are unable to form ridesharing arrangements and may lead to serious legal issues.
- Employers are concerned that subsidies and special fringe benefits may become a bargaining issue in employee contract negotiations.
- Legislation on the Federal and/or State level would be necessary for special vanpool changes in the investment tax credit and rates and personal tax deductions for privately operated vanpools.
- Transit agencies and labor unions may oppose financial subsidies because of the fear of patronage losses and resulting cut backs in the fixed route transit system.

Public acceptability. Financial incentives in the form of subsidies or fringe benefits are well received by ridesharing commuters. The opposition arises among drive alone commuters who feel that ridesharers receive special benefits not afforded them. This is strongly voiced among commuters who live in areas where the potential for finding other riders is very low and those who work irregular or odd shifts. The Greyhound Corporation in Phoenix, Arizona was forced to reduce their subsidy to ridesharers when drive alone commuters complained that they were unable to form pools and felt they were being discriminated against.

Employers approach this issue with hesitation because of this and also due to the fact that subsidies can become an issue and negotiable item in employee labor contracts. Employers in most cases will not adopt a subsidy program unless they have severe problems with parking or traffic congestion that causes difficulty in maintaining their labor force.

The general public as a whole may become concerned if a subsidy program were implemented by a large governmental agency since they might view this as a wasting of tax dollars. It seems doubtful that a governmental program of this type could be implemented without receiving a substantial amount of criticism.

Preferential Traffic Control

Description. The concept of priority techniques for high occupancy vehicles has been practiced for many years with most facilities accommodating only buses. More recently carpools and vanpools have also been allowed. Among the primary advantages which can be realized

by the application of priority techniques for buses, carpools and vanpools are: (1) increased efficiency of existing highways and vehicles; (2) relatively low capital investment requirements; (3) short lead time in the planning and implementation of projects; (4) flexibility in adapting or terminating unsuccessful projects; (5) decrease in user travel times; and (6) increased reliability of transit service.

Priority techniques can be categorized into three distinct application areas; freeways, arterials and activity centers. The major types of freeway techniques are: (1) separated exclusive rights-of-way facilities; (2) concurrent-flow and contra-flow re served lanes; and (3) priority freeway access control, including bypass lanes on metered ramps, or exclusive use ramps. Arterial applications include techniques employed on heavily traveled streets connecting urban and suburban residential areas with major commercial or industrial areas, and other major traffic generators. Concurrent and contra-flow reserved lanes, and signal preemption are the most common arterial applications. Activity center applications include priority techniques implemented on city streets within dense urban locations such as central business districts, major commercial/industrial centers or airports. Activity center applications include systematic reserved lanes for circulation systems, transit malls, street terminals as well as many of the techniques which apply to arterial streets.

Market identification. Preferential treatment for carpools and vanpools has to date been tied directly to priority treatments for buses. To justify a reserved lane, the corridor must carry a greater

number of people than carried prior to reserving the lane. In most instances preferential lanes for only carpool and vanpool use would not be capable of generating this demand and would result in a decreased level of service and additional congestion problems. Consequently priority techniques which employ reserved lanes or ramp bypasses are applicable in areas with substantial bus service.

Criteria which should be considered when allowing carpools and vanpools on preferential bus facilities are: (1) carpools and vanpools will not adversely affect public transportation patronage; (2) the travel time advantage to buses will not be lost; (3) safety will not be jeopardized; (4) adequate enforcment can be accomplished; and (5) reserved facility or lane has plenty of excess capacity.

The application of priority treatments for carpools and vanpools has its greatest potential on freeway and arterial reserved lanes and priority access ramps. In most circumstances carpools and vanpools can be easily accommodated on these facilities and result in some travel time savings. This reduction in travel time may be minimal and result in little incentive for carpools and vanpools to use reserved lanes on arterial streets if buses make frequent stops to board passengers.

Signal preemption, activity center circulation, and reserved lanes have limited application to carpools and vanpools. For carpools and vanpools to take advantage of signal preemption, a reserved lane must be in use with a magnetic loop detection system to detect vehicles in the priority lanes. A simple signal preemption system triggered by a special unit in each bus would not be feasible for carpools and vanpools. Activity center reserved lanes and priority

circulation systems offer some travel time savings but with constant stopping of buses, offers little incentive to vehicles other than local buses.

Freeway priority treatments are most applicable in large metropolitan areas where extensive freeway networks exist. Suggested demand for a reserved bus, carpool, and vanpool lane is in the range of 40 to 60 buses per hour carrying from 1,600 to 2,400 passengers per hour as a minimum (NCHRP, 1975).

Reserved lanes on arterials are applicable on streets with a minimum of five lanes, one being the reserved lane. The need for five lanes is based on the condition that if only one lane is left open for regular traffic an accident or stalled vehicle in that lane would force vehicles into the priority lane reducing its effectiveness and increasing accident potential. Suggested demand on arterial streets is 20 to 25 buses per hour (NCHRP 1975).

In medium and small sized urban areas, priority techniques may have their greatest potential through application on a problem specific basis. Applications may include isolated signal modifications, special turning privileges, or short length reserved turn lanes. Each urban area will differ and application areas should be identified as to their potential in reducing congestion and providing an incentive for individuals to use some form of ridesharing.

Implementation. Priority treatments such as reserved lanes and ramps are for the most part low cost projects which utilize existing facilities. The primary costs are for minor construction changes and installation of traffic control devices. Separate freeway lanes are

by far the most extensive and costly facilities and can be justified in only the largest urban areas. Concurrent and contra-flow lanes which utilize existing freeway lanes are less expensive with costs ranging from $10,000 to $30,000 per mile. Priority ramp access costs range from $4,000 to $8,000 per ramp for signing and stripping. Projects which include ramp widening and/or provision of signal equipment range from $10,000 to $80,000 per ramp.

Reserved lanes on arterial streets can be provided at minimal expense since costs usually involve only signs and pavement markings. Concurrent-flow lanes are usually less costly to maintain and operate than contra-flow lanes. Arterial as well as freeway contra-flow projects which operate only in peak periods will probably involve setup and take down operations of barriers. Costs of this operation can be expected to run $1,000 to $3,000 per mile per month. Besides being expensive this operation can be quite disruptive and congestion producing.

Priority treatments which do not involve extensive construction or signalization can usually be implemented within a year. Priority treatments are usually implemented in conjunction with other strategies such as park and ride lots and carpool matching programs and expected results may not materialize until the entire ridesharing program has matured.

Concurrent-flow lanes are more applicable for use by carpools and vanpools on both freeway and arterial facilities because of the reduced conflict with opposing vehicles. Allowing carpools and vanpools on contra-flow lanes creates a potentially dangerous situation for head on collisions. Carpool and vanpool drives may be less attentive to opposing traffic than trained bus drivers.

Arterial techniques generally affect a broader spectrum of nonusers than do freeway techniques and limits to an extent their application. In identifying possible arterial streets the following impacts should be considered: removal of peak period or all day parking may be difficult to accomplish and may result in opposition from abutting businesses and residents; goods movement may be adversely affected during periods of lane operation; accidents may increase if the densities of nonuser vehicles is increased; nonusers may initially experience significant increases in travel time; nonuser turning movements may become more difficult to negotiate; traffic on parallel facilities may increase; access to adjacent properties may be impaired; and enforcment may become difficult and expensive.

In the case of reserved concurrent-flow lanes which accommodate carpools and vanpools the best position of the lane is either the inside lane (closet to the median) or in a median lane. Reserved lanes in these positions favor express bus operations, carpools and vanpools because frequent stops for loading and unloading local bus riders would be avoided. Placement in the curb lane with local bus service would cause frequent stopping and loss of travel time savings which would serve to reduce the incentive to use the reserved lane. In small and medium sized urban areas the implementation of priority treatments is limited and probably is best directed at isolated problem areas rather than corridor applications.

Funding for priority treatments can be obtained through either the Federal Highway Administration (FHWA) or Urban Mass Transportation Administration (UMTA). Federal Highway Administration funding includes interstate, urban system, or federal aid primary funds which

range from 70 percent to 90 percent federal financing. Federal Aid Highway funds are also available from the FHWA to defray additional enforcement costs and other operational and maintenance costs of the demonstration time period of projects which test or exemplify priority techniques of general interest and applicability.

The Urban Mass Transportation Administration may make grants covering up to 100 percent of the net costs during the demonstration period for projects which test or exemplify priority techniques.

Institutional/legal barriers.

- Enforcement agencies should be involved in the early stages of planning for priority treatments. This involvement is important in developing an effective enforcement program and avoids conflict between enforcement agencies.
- Developing new traffic patterns are usually within existing police powers. In some in stances (priority lanes) special state enabling legislation may be necessary to reserve certain portions of a public roadway for specific users.
- Traffic engineers may resist significant system changes because of concerns that serious operational problems will result.
- Abutting merchants and property owners must be properly educated on the proposed project and involved in its planning to avoid adverse impacts and strong objections.

- Transit operators should be involved in program planning to assure strategies can conform to current and projected transit routes and operations.

Public acceptability.

- Users as well as nonusers are receptive to the majority of priority treatments. In instances where travel times or congestion are significantly increased for nonusers, public objections could be strong and may force the project to be discontinued. Extensive analysis must be made concerning the expected impact on nonusers and an effective educational program should be undertaken to avoid adverse public reaction and project failure. Implementing a project after an initial failure is a difficult if not impossible task.
- Priority access ramps and lanes are less controversial and more common than freeway priority lanes because they affect a fewer number of nonusers.

Park and Ride Facilities

Description. Traditionally park and ride facilities consist of a park and ride lot where commuters park their automobile and transfer to a transit mode. The park and ride lot collects private automobile riders in low density residential areas and provides a point for riders to transfer to transit for the heavily congested portion of their trip. The park and ride lot draws riders from a relatively large market area to a point where there is enough concentrated demand

to support transit. These facilities range from parking areas at gasoline stations, drive-in theaters, shopping centers and churches to specially constructed parking lots with varying degrees of amenities.

The concept of collecting commuters at a central location and transfering them to another more efficient mode can be applied to carpooling and vanpooling. Park and ride facilities commonly used for transfer to transit can also be promoted as a meeting place for carpoolers and vanpoolers. Small lots without transit service can also be designated as meeting places for commuters to form ridesharing arrangements.

To increase the capacity of park and ride lots serviced by transit and increase their effectiveness in reducing vehicle miles of travel and pollution, carpool and vanpooling can be encouraged for the home to park and ride lot portion of the trip. By encouraging commuters to carpool to the park and ride lot rather than driving alone or being dropped off, facilities can operate at greater capacity and transit operations may experience an increase in ridership due to the greater promotion and accessibility of park and ride facilities. Energy consumption and automobile pollutants will also be substantially reduced if commuters rideshare to the lot since cold engine starts and mileage to and from the lot will be reduced. A major drawback of current park and ride facilities is that many commuters drive alone or are dropped off at the lot producing minimal reductions in energy consumption and pollutants.

Current carpool matching programs can be altered to include information on convenient park and ride lots and an additional list of commuters common to a lot can also be produced.

Market identification. Carpool matching is applicable to most park and ride lots serviced by transit. Markets which are suited for park and ride transit operations are usually large and medium sized cities that have a substantial CBD employment, areas that have a heavy traveled corridor with a single destination, and large remote employment centers with oneway commuting distances greater than 10 miles.

In addition to these characteristics, an area should possess high parking costs and a low supply of parking. Unless travel distances are long and congestion heavy, commuters will continue to drive to the employment site if parking is available or inexpensive. The increase in travel time by the change of mode, the bus fare itself, and the loss of mobility appears from current operations to be offset substantially by destination parking cost and supply. Smaller park and ride lots without transit service are applicable to all sized cities and most likely already exist at convenient transfer points close to freeways or major arterials. Through official designation and promotion of these lots an increase in their use can usually be expected.

Implementation. Carpool matching to park and ride facilities is easily accomplished by identifying the locations of the nearest facilities on the home to work carpool match list. The match list should indicate the park and ride facility as being a lot where carpool and vanpool riders can meet to form their pooling arrangement or one where commuters can carpool or vanpool to and transfer to transit for the remaining portion of the work trip. An additional list of commuters passing a particular lot should also be included since it increases the number of other commuters who may be interested in ridesharing

from the area surrounding that lot. The inclusion of this information increases the number of commuting alternatives available to commuters and results in a more effective and comprehensive ridesharing program. The City of Houston in their ridesharing program provides this type of park and ride information on matching lists.

Park and ride lots which are serviced by transit, usually exist in heavily traveled corridors and are located in shopping centers, recreation or sporting facilities or specially constructed parking lots. Most successful bus lots are located within one-half mile of an expressway in order to provide easy access to the lot by both commuters and the bus. The location of park and ride lots from the destination, usually the CBD, is dependent on travel time, distance, and traffic congestion. In the case of bus service without preferential treatments such as exclusive lanes, travel time by bus may be greater than automobile. Therefore the park and ride lot should be located just outside the areas where congestion starts to occur on the freeway so relief from traffic congestion can become an incentive for changing modes. If the lot is located too close to the destination, the bus portion of the trip will be short and rather than bother with changing modes and transfer time, commuters will drive directly to work. If the lot is too far out, travel time by automobile may be much shorter than the bus. As a minimum, remote park and ride lots should be located at least three to four miles from the destination.

Park and ride lots without transit service tend to be smaller and located in corridors that are less traveled or on the outer edges of heavily traveled corridors. Lots are usually smaller and located in church parking lots, gasoline stations, small shopping centers or

small specially constructed park and ride lots at freeway interchanges. Identifying these smaller lots is best accomplished by observing locations where commuters are already using parking lots as meeting points and then designating them as official park and ride lots. There are usually many points throughout a community that commuters are using as meeting points, but before they can be identified as park and ride lots on match lists they must be officially designated.

Joint-use park and ride facilities are less expensive than specially constructed lots but may be difficult to establish because the cooperation of parking lot owners is required. At times ideal locations are found but parking lot owners are reluctant to forming agreements. In many areas, joint-use lots have been successfully established at shopping centers, gas stations, and churches. Many shopping centers have experienced an increase in retail sales resulting from park and ride users shopping at these stores. Joint-use lots also have an advantage over specially constructed lots in the event the park and ride operation proves unsuccessful. In this event the contract can simply be terminated with the lot owner and the lot returned to its normal use. Specially constructed lots on the other hand must be disposed of or converted to another use usually with a loss of the original capital cost of constructing the lot. The City of Portland has extensively used joint-use lots at shopping centers and churches for park and ride operations with and without transit service.

Institutional/legal barriers.

- Transit agencies and unions may object if carpool matching from park and ride facilities to the work destination diverts rides from transit. This could easily happen if travel costs and time are similar.
- Liability issues arise in joint-use facilities over items such as accident liability, parking lot maintenance, lighting, snow removal and pavement marketings. To avoid these issues a contract should be negotiated between the operator of the park and ride service and the owner of the parking lot specifying which party will be responsible.
- Churches, gas stations, etc. have approached joint-use park and ride facilities with mixed reactions. It appears that each area exhibits a different reaction to joint-use facilities with individual locations, the local environment, and the owners themselves being primary factors in making a decision.
- Downtown parking lot operators in many cases have welcomed park and ride facilities since it has opened up parking spaces for short-term parking which produces greater revenue than long-term parking.

Public acceptability.

- Park and ride facilities have been accepted favorably by both users and nonusers. The only objections occur if lots are located too close to residential areas and surrounding residents complain of increased traffic and congestion.

Parking Management Strategies

Description. Parking management is a concept related to the goal of achieving a better balance between automobile use on the one hand and transit, ridesharing, bicycling and walking on the other. Simply stated, a parking management strategy is an action taken to alter the supply, operation, and/or parking demand of a jurisdiction's or private employer's parking systems to further the attainment of local transportation, economic, environmental, and other applicable objectives. In respect to ridesharing, strategies attempt to tailor the supply of parking to demand so as to increase the price or reduce the availability of parking in order that automobile drivers have an added incentive to shift to other modes. Strategies that can be incorporated in a parking management plan include the following.

Limiting New Parking Spaces: This strategy focuses on limiting the supply of new parking spaces through zoning ordinances or special restrictions. New parking supply can be limited through zoning ordinances that limit the maximum number of spaces for new developments or which place a ceiling on the number of spaces within a specified area such as the CBD. Restrictions could also be placed on construction of principal-use (i.e., stand alone) parking facilities.

On-Street Parking: On-street parking controls involve measures that add or remove spaces; change the mix of short and long-term parking; restrict parking during specific periods of the day (peak/off-peak), alternative side parking by time of day and/or day of week, permissible parking durations, and prohibitions on parking before specified hours; and residential parking permit programs to restrict the overflow of commuter vehicles into residential areas.

Auto Free Zones or Restricted Areas: Certain portions of an area (usually the CBD) can be designated as restricted zones where limitations are placed on traffic and parking use. These restrictions can pertain to a few select street blocks or an entire area. Restrictions can also be placed on parking lots and garages by delaying their opening until after employees start work, thus reducing the supply of commuter long-term parking. Exemptions can be made for certain classes of vehicles such as transit vehicles, delivery vehicles, taxis, vanpools, carpools, emergency vehicles, and residents requiring access to the area.

Preferential Carpool/Vanpool Parking: Preferential parking involves designating special areas for carpoolers and vanpoolers to park at their work site that enhances the convenience of parking. This convenience can take the form of reducing walk time by assigning the closest spaces to poolers, assuring poolers of a guaranteed parking space when parking is scarce, provide covered or reduced parking costs when compared with current parking changes. On-street preferential carpool/vanpool parking can also be supplied through special designation and permit programs.

Increase in Parking Rates and Parking Surcharge Tax: The objective of these measures are to raise the cost of parking to long-term users. Increases in parking rates can be applied to long-term rates while maintaining short-term rates at current prices. Increasing rates is most applicable to publicly owned facilities since legislation would most likely be necessary for application to private operators. A parking surcharge tax can be applied to all available commercial parking in an area as a means of increasing parking costs and generating additional municipal revenues.

Market identification. Parking management strategies are most effective at high density employment areas like the CBD or regional activity centers. Areas with scattered employment and a large supply of free parking are usually poor candidates since the incentives for ridesharing would be difficult to create. Central business districts with a low supply of parking and high prices are prime candidates for many strategies since disincentives to driving alone are easily created. At large isolated employment sites, various strategies maybe applicable such as preferential parking or reducing the supply of parking and subsidizing alternative modes. Each site should be examined individually since managements receptiveness plays a key role in proposing and selecting strategies.

For parking strategies to become successful an alternative mode of travel must be readily available to commuters. If transit coverage is poor and ridesharing programs nonexistent, parking strategies will meet intensive public objections and most likely result in failure. Therefore, an area must possess or have the capabilities of developing a strong transit and ridesharing program before parking strategies are implemented.

Limiting New Parking Spaces: This strategy is applicable to most communities and is not dependent on parking supply, price, city size, or employment densities. Its greatest potential is in areas where new development is expected to occur.

On-Street Parking: This strategy most likely already exists in portions of most CBD's and its implementation would be to expand the application to a larger portion of the CBD. Eliminating on-street parking may be applicable only on those streets which possess a high volume of traffic or which are used extensively by buses. Entirely

eliminating on-street parking will most likely create objections from local merchants and cause their sales to decline. To avoid this, parking could be limited to short-term use or prohibited during the morning peak hours in areas of retail development. A residential parking permit program is applicable if a residential area is within close proximity to major parking generators such as employment centers, universities, hospitals, retail trade centers and transit terminals. Determining permit boundaries is dependent upon the feasible walk limits for nonresident parkers and may require adjustments as parkers choose to store their autos farther and farther away from parking generators. As a rule of thumb, a one-half mile distance from a generator is a good starting point for permit boundaries but may vary depending on city size.

Auto Free Zones or Restricted Areas: Auto free zones are applicable in areas with small or large CBD's. Most applications are limited to one or a few streets in the downtown or regional employment centers. The auto free zones are usually converted into shopping malls with no or limited access by delivery trucks and buses. Entire downtown areas could be designated as an auto free zone but current attitudes toward accessibility prevent its occurance.

Preferential Carpool/Vanpool Parking: Preferential parking is applicable to many different employer types, sizes, and locations. The most effective sites for implementation are those areas where parking is scarce, costly or inconvenient enough to make preferential parking privilages attractive. These may include areas such as the

CBD where parking costs are high and/or scarce or employers with large parking lots and long walking times from the parked vehicle to the plant. At sites possessing abundant free parking there is little incentive in having a preferential space. Preferential programs are low cost requiring no direct monetary payment and can consequently be implemented easily by many public and private agencies without controversy.

Increases in Parking Rates and Parking Surcharge Tax: These strategies are applicable to most areas regardless of employment size or parking supply, but favors those areas where land values and parking charges are higher. Applying parking rate increases or surcharge taxes is best suited for the CBD or regional activity center where congestion problems occur rather than applying them on a city or region wide basis. In most cases region wide application would be politically as well as functionally unfeasible due to the lack of alternative commuting modes.

Elimination of Employer Subsidies: This concept is applicable to most employers regardless of size or location. The greatest impact would be employers located in areas where land values and parking costs are high. Employers in these areas maybe more receptive to the strategy since there would be greater savings on their behalf if parking subsidies were eliminated since the cost of leasing or providing parking is usually quite expensive.

Implementation. In selecting parking strategies a careful analysis is necessary to identify the numerous constraints and impacts

associated with each measure. Strategies are seldom implemented individually but rather work together to complement one another and form an overall effective parking program. Reducing parking supply at lots and garages would be more effective if strategies preventing on-street parking and spillover into residential areas were also implemented. Besides coordinating parking strategies among themselves, support strategies must also be considered to enhance the attractiveness of other modes of travel. Ridesharing and transit programs should be implemented and promoted so as to provide viable options. Enforcement measures are also necessary to discourage illegal parking.

The first step in selecting appropriate parking controls is to identify existing characteristics of automobile traffic in the study area. The current supply and demand for parking must be measured along with the availability of alternative modes such as local transit and specially ridesharing. Data considered useful in identifying existing and future characteristics includes land use and activity level information, parking inventories and occupancy rates, and traffic and transportation system characteristics. A data collection effort which encompasses all of these areas is essential in determining the costs and benefits of control plans as well as social and institutional impacts on the community.

The identification of socioeconomic impacts and implementation barriers are key considerations to developing an effective plan. The legal powers which are available to control parking in the study area

should also be examined so that coordination between levels of government can be obtained when changes in laws and policies are required. Regulations which often require changes include control of on-street parking, taxation and licensing, enforcement, new enabling legislation, and residential parking permit programs. Control plans in most circumstances will produce varying impacts on the surrounding residentail areas, commercial development, and existing transportation systems. Reducing or restricting parking may divert commercial development to areas where there is a greater supply of parking. Developers may perceive that the low supply of parking may reduce the potential labor market or divert shoppers to areas with ample parking. Surrounding residential areas may object to control plans which produce a spillover of commuter vehicles into their area. A residential parking ban can help overcome this problem but objections will still exist. Local transit systems must be examined to determine if additional ridership can be accommodated in the peak periods. If excess capacity exists during this period addition riders can be accommodated easily and transit deficits will decrease. If the opposite is the case and new buses are necessary, deficits can be expected to increase. Ridesharing programs must also be capable of handling additional requests with quick turnaround time. The lack of alternative commuting options will result in greater public objections and program failures.

Parking control programs have the potential to produce a significant shift to transit and ridesharing modes if an enforcement element is included. Plans can be developed which produce extensive deterrents to driving alone and force commuters to higher occupancy forms

of travel. Strong deterrents may also also produce adverse impacts by reducing mobility and can be met with extensive public objections that cause strategies to be nonimplementable. Gradual changes in parking policies that reduce mobility to a lesser extent have more potential for public acceptance and implementation. Strategies which gradually, rather than abruptly reduce parking supply are more acceptable to affected groups. Proposing even gradual changing strategies may stimulate objections from commuters, parking lot operators, and commercial developers and in most areas makes implementation difficult.

The remainder of this section is devoted to specific discussions on implementation for each parking control strategy.

Limitating New Parking Spaces: This strategy is primarily aimed at new parking facilities being constructed in conjunction with commercial development. To limit new parking supply, zoning ordinances must be changed to lower the minimum and maximum amount of parking that can accompany new structures. Traditionally zoning measures attempt to insure an adequate supply of parking to prevent spillover into neighboring development or public streets. To successfully implement a reduction in the number of spaces and influence commuters to shift to alternative modes, supporting strategeis such as residential permit programs and elimination of on-street parking would need to be considered. Limiting future supply in this manner is a gradual approach with expected reductions in auto use tied directly to the amount of new development expected to occur. Portland, Oregon, San Francisco, California, and Seattle, Washington have all inacted ordinances that eliminated minimum parking requirements and placed a

maximum number of allowable spaces in the downtown area (Di Renzo, 1979).

Another method of limiting new supply is to ban construction of new parking facilities in a specified area. This ban would most likely be in the form of city policy or ordinance and enforced through denial of building permits or zoning request changes. Boston, Massachusetts and Portland, Oregon have enacted such restrictions by placing a limit on the total number of parking spaces within the CBD.

If changes in zoning ordinances cannot be obtained, special exemptions can be granted to new developments reducing the minimum number of required spaces.

On-Street Parking: Prior to implementing strategies which deter the drive alone commuter, a system must be developed to close the excape hatch of free and available on-street parking spaces. Eliminating on-street parking can be accomplished in two ways. The first is to completely remove parking from the street for all purposes. The advantage to this approach is increased capacity of the street network and easier movement for buses. The disadvantage is the inconvenience to shoppers who previously used on-street parking. To avoid this problem, on-street parking can remain but designated for short-term use only. This approach provides shoppers a parking place and reduces the impact on local merchants. Parking could also be restricted during the morning peak period which would discourage long-term parking and keep parking available for short-term shopping.

The areas in which on-street parking should be banned depends on local conditions but should be large enough to encompass commuters who

are most price sensitive and willing to walk extra blocks to get free parking. The expected reductions in auto use are tied to the number of on-street parking spaces eliminated and other accompanying strategies. This strategy can be easily intergrated into transit improvement or street widening programs in the CBD, and consequently receive less negative reaction than if inacted separately.

Residential permit programs are usually inacted to prevent the spillover of commuter vehicles and reduce auto traffic in abutting residential areas. Besides preventing commuter spillover and easing congestion, permit programs eliminate a source of available free parking for commuters. If residential areas are within walking distance, a permit program will be necessary if other controls are to become effective.

Permit programs are easily implemented by issuing area residents special parking decals for their automobiles. The permit allows residents on-street parking and quickly identifies vehicles not residing to residents of the area. For the permit program to become effective severe fines and strict enforcement is also necessary. Objections to the permit program are usually voiced initially by area residents since added controls and restrictions are bothersome. Through proper education of the benefits of the program, negative criticism can be reduced and the program implemented successfully. Permit programs have been implemented successfully in numerous cities such as Alexandria, Virginia, Boston, Massachusetts, San Francisco, California, and Washington, D.C.. The primary aim in implementing these programs was to eliminate the spillover of commuter vehicles in residential areas and has been received quite favorably by residents.

Auto Free Zones or Restricted Areas: Implementing auto restricted zones can be a time consuming process requiring extensive planning and design and the development of supporting facilities such as street modifications, fringe parking, and internal distribution systems. Several years are usually devoted to system planning prior to detailed design and implementation. This long start up time is attributed to the necessity of coordinating efforts with many separate departments or agencies responsible for planning and zoning (traffic, transit, police, and utilities). Private interests of retailers, employers, and freight delivery companies also must be considered in the decision process.

Actual costs of restricting traffic can vary widely depending on the level of construction. Restrictions on a large scale may be extremely high, primarily due to support facilities such as an alternative transport system into and within the restricted zone, preferical parking facilities and major street reconstruction.

Auto restricted zones primarily divert rather than eliminate auto traffic. Application in most U.S. cities would be to only one or two major streets in a downtown area. Restricting traffic to a larger area would create substantial objections from area business and commuters and be politically unacceptable. Through this limited level of application, auto free zones would only reduce on-street parking supplies. Small scale auto restricted zones have recently become popular in many U.S. cities and implemented in conjunction with downtown redevelopment programs. As these programs grow and become successful, restricted zones on a larger scale may become more popular and politically feasible.

Preferential Carpool/Vanpool Parking: Preferential parking is an immediate action strategy that can be implemented voluntarily by a wide range of employers at little cost. Employer effort in setting up and administering the program is modest. The cost of administration, enforcement, and physical signing is nominal and technically simple. Enforcement presents some problems in areas where parking supply is not critical and self-enforcment is lax. In this case spot checks and continued renewal of parking privileges is necessary.

For preferential parking to stimulate new ridesharing arrangements it should be implemented in conjunction with a program of matching commuters so new pools can be easily formed. If implemented by itself, the program usually attracts existing rideshares with other employees finding it difficult to form pools on their own. To continually encourage new ridesharing arrangements, the supply of preferential parking should be sufficient to meet demand rather than being fixed at a certain level. Preferential spaces can also be provided by municipal governments at publicly owned facilities or on-street locations. Special spaces can be designated for carpools and vanpools and permits issued through a local governmental agency after verification. Portland and Seattle have implemented on-street parking programs for carpoolers (three or more people) or vanpools. Basically, these programs allow participants to park all day at specific downtown metered locations for relatively small monthly fees.

Preferential parking even when implemented in conjunction with matching programs has minimal effect in stimulating new pooling arrangements. Strategies such as financial incentives have a far greater

impact. The offering of preferential parking can be a first step in encouraging ridesharing and when coupled with other strategies provides a strong incentive to ridesharing.

Increase in Parking Rates and Parking Surcharge Tax: Increases in parking rates is most applicable in areas where a large proportion of the parking is supplied by local governments since control over rate setting is essential. Governments will probably have little ability to increase rates in the case of private operators without state legislation which probably could not be obtained at least in the short-term. The means of controlling private operators would most likely fall under the public service commission with regulation similar to taxi operations.

Increasing rates is a strong deterrent to driving along since commuters are somewhat sensitive to parking costs. To become effective, rate increases must be accompanied by programs that eliminate free on-street and residential parking. A large proportion of parking must fall under the rate increase or commuters will merely be diverted to lower priced lots. A drawback to this strategy is its inability to affect free parking provided by employers and the expected public objections to rate increases. Public agencies must also be concerned with reducing parking in public garages to levels which are not capable of generating revenues to cover bond payments. Honolulu, Hawaii and Montgomery County, Maryland increased municipal parking rates which increased parking revenues substantially but had little initial effect in forming new ridesharing arrangements since commuters found alternative less costly parking facilities. Short-term parking for shoppers has increased as a result of the price increases.

A surcharge tax on parking has the same effect as raising parking rates only the method is different. A surcharge tax could be implemented in a relatively short time period through passage of appropriate legislation similar to that of a city sales tax. The cost of administering and collecting the tax would be relatively small in relation to tax revenues. Collection of taxes would be similar to sales taxes with parking facility operators being responsible. There is no legal reason why local governments cannot apply parking surcharge taxes on parking lots except that a surcharge program is considered a politically unacceptial issue by most decision makers. The City of San Francisco implemented a 25 percent parking surcharge tax but was later forced to lower it to 15 percent. Washington, D.C., and Pittsburgh, Pennsylvania have also implemented surcharge taxes from 12 to 20 percent on parking lot partons who pay for parking.

Parking surcharges can be applied to public and private suppliers as well as employers who provide parking. Both commuters and private lot operators will object to a surcharge tax. Lot operators are concerned that a surcharge will reduce parking demand and consequently lower revenues below the break even point. If this were to occur, public funds might be necessary to compensate operators for their loss.

Parking surcharge taxes may vary within an application area with higher taxes in areas most congested or were auto use is being discouraged. Rates may also vary between long and short-term duration or by time of day with peak hour rates being highest.

Surcharge taxes, to be effective must be implemented with supporting strategies and employer cooperation to discourage them from absorbing the surcharge tax for employees.

Elimination of Employer Subsidies: This strategy is difficult to implement since it requires voluntary action on behalf of employers. To encourage elimination, an intensive educational effort is necessary to show employers how elimination of parking subsidies will benefit themselves, employees and the community. All three parties can experience economic benefits arising out of increased ridesharing and reduced need for parking spaces.

There are several methods of eliminating subsidies which could be put into effect by employers and include the following:

- Apply the money currently spent for parking subsidies to equal pay increases for all employees. Thus allowing employees to pay directly for their parking or other transport expenses.
- Apply the money currently spent for parking subsidies to transportation subsidies for transit, vanpooling, or carpooling.
- When new faciliites are being constructed or leased, provide less or no parking for employees and use this money for subsidies on transit, carpooling, or vanpooling.

If employers currently own or lease parking for employees it will be difficult to convince them to discontinue a subsidy program. The most promising approach is to discourage additional parking when

new facilities are being constructed or not renewing leases on parking facilities and applying this money toward a company subsidized ride-sharing program. In many cases this type of subsidy program is less expensive than providing parking. The Tennessee Valley Authority has taken this approach at their Knoxville, Tennessee headquarter's and has resulted in much success and savings for both commuters and themselves. American Hospital Supply Corporation in Evanston, Illinois has eliminted free parking for employees and increased salaries $554 annually (before taxes) as compensation for nonsubsidized parking.

Institutional/legal barriers.

- Private parking lot operators will object to strategies such as price increases or supply reductions since they will reduce their revenue. If private operators are adversely affected by strategies, public funds may be necessary to compensate operators.
- Municipal parking operators must be aware of the potential of reducing parking revenues to levels insufficient to meet bond payments. This would consequently require an added public subsidy to municipal parking facilities.
- There is considerable uncertainty surrounding the question of whether a jurisdiction can exercise rate control over private lot operators. A possible means of doing this is to regulate parking as a public service.
- Surcharge taxes on parking rates would most likely be legal under local police powers, but most jurisdictions would need to seek specific state enabling legislation.

- Commercial developers and retail merchants will oppose strategies that reduce the accessibility of their establishments by shoppers and employees. Economic development may be slowed or diverted to other areas if parking availability is low or highly priced. Developers are fearful that the available labor force will be reduced because employees will be unwilling to work in an area with high parking rates and low supply. This may inturn reduce the market value of land in the area.
- In the case of preferential carpool/vanpool parking, labor unions or employee associations should be consulted in the planning of such actions to avoid the problem of benefits being differentially applied or given to only a fraction of employees. Another potential conflict is management personnel who currently have preferential parking and fear loss of their space and resist the program.
- Municipalities may encounter legal problems over authority to implement residential parking permit programs. State enabling legislation may be necessary in these cases.
- Changing zoning requirements most likely will be a time consuming, political battle that will be difficult to implement.

- Eliminating employer parking subsidies is strictly a voluntary action since it represents an interference with personnel practices that may affect the ability to compete for skilled labor in high parking cost areas. Owners and operators of office complexes would also oppose this measure as a potential reducer of revenue.
- The ability to coordinated the many different agencies responsible for parking such as traffic engineering, planning organizations, transit systems, police and fire department, and local elected government officials will create barriers.
- A parking surcharge tax may be regressive since low-income persons who drive would pay a substantially higher percentage of their income for the surcharge.

Public acceptability

- The public can be expected to object to any strategy that will raise the price of parking or make it less available. Most of the parking strategies that limit the availability either through price or supply fall into this group and strong objections can be expected from commuters as well as many shoppers and local merchants. Limited versions of some strategies such as closing one or two downtown streets to make a shopping mall have recently become publicly acceptable but full scale auto free zones would be politically unfeasible.

- o Current transit users may welcome parking strategies if improvements in the level of service are planned such as reduced headways and new routes. On the other hand, increased ridership without transit improvements may bring about objections from transit users due to the crowded conditions and slower travel times.
- o Auto users not able to rideshare or use transit, will find parking extremely high priced and difficult to find, causing severe impacts upon them.

Facility or Area Tolls

Description. Facility or area tolls are programs which attempt to achieve a more efficient utilization of street and highway space through restricting travel and encouraging use of high occupancy vehicles. Two basic forms of this policy have been suggested or implemented: (1) tolls or taxes are imposed on vehicles which drive on specified facilities in designated areas. This is commonly referred to as congestion pricing where vehicles are charged some fee for driving in designated areas, most commonly the CBD; or (2) tolls are raised across the board for all vehicles or charged differently on existing toll facilities (bridges, tunnels, or tollroads) to give preference to carpools, vanpools and buses.

Congestion pricing is a concept which attempts to recover the congestion costs motorists impose on other users that are not covered in gasoline and other auto related taxes. The cost that added congestion creates is related to additional roadway capacity and maintenance, community disruption, and air and noise pollution. By taxing

individuals who desire to drive in these selected areas, a disincentive to driving is created and individuals must either pay the fee or shift to higher occupancy forms of transportation where the costs are shared among more people. Congestion pricing is considered an extremely impractical strategy by most decision makers due to anticipated public objections and lack of political support. On an area wide scale, which would be necessary for an effective program, individuals would not be receptive to a strategy that restricts or prohibits the use of their private automobile. Research efforts have developed administrative schemes to implement congestion pricing and it appears the legal authority is also present but lack of public support prevents its application (Bhatt, 1976).

Differential toll charges are a more accepted means of encouraging the use of high occupancy vehicles. Under this pricing mechanism tolls are adjusted by usually charging a lower or no toll for buses, carpools, and vanpools on existing toll facilities. Another but less accepted version of this strategy is to raise the toll for all vehicles.

Market identification. Adjusting toll fees is limited to areas which currently have toll facilities. It would be extremely difficult if not impossible to initiate a toll on a facility that previously did not have one.

Implementation. Toll adjustment measures are usually implemented easily with approval of new toll fees by the controlling agency the only major action. For the strategy to become effective supporting

programs must also be undertaken. These include: promotional campaigns informing commuters of the new tolls; ridesharing programs to help commuters expand or form new pools; transit improvements to handle additional riders and make the system more attractive and; preferential lanes on the toll facility could be opened for high occupancy vehicles.

To encourage high occupancy vehicle use, especially carpools and vanpools, commuters should have some mechanism such as a ridesharing program to help them expand or arrange new pools. It becomes difficult for commuters to form new pools if they are left on their own to find someone else. Lack of accompanying support programs will in most cases prevent the strategy from reaching its expected potential.

Determining the expected increase in new carpool formation is difficult since existing projects have been implemented in conjunction with other strategies such as preferential lanes and toll booths which create travel time savings. This has been the case in Seattle, Washington on the Evergreen Point, Floating Bridge and San Francisco, California, San Francisco-Oakland Bay Bridge where priority lanes and toll booths were implemented in conjunction with reduced toll for ridesharers (California, 1979).

Current operating experiences have found that many carpools have been diverted from alternative routes rather than forming new ridesharing arrangements. As a result consideration should be given to the issue of diverting riders from transit and the impact on existing transit operations.

In establishing differential fares careful consideration should be given to the impact on future revenues and the ability to meet bond indenture requirements. On the San Francisco-Oakland Bay Bridge, reduced carpool fares were increased for a period of time in order to meet bond obligations (California, 1979). Raising tolls on single occupant cars to compensate for reduced revenue from ridesharing vehicles, stimulates extensive objections from single occupant motorists and is considered politically unacceptable.

The cost of implementing differential fares is minimal with advertising and promotional efforts being the major expenses. In most fare structures total revenues from tolls will decrease and the ability to sufficiently operate the facilities should be considered.

Institutional legal barriers.

- There are no major institutional barriers to implementing toll changes on existing toll facilities. The most likely problem to occur would be obtaining the fee change from the authority operating the toll facility.
- Congestion pricing strategies would receive objections from motorists, area employers, commercial developers, parking operators, and low income individuals. Employers would fear the diversion of employment to outlying areas. Retail businessmen and parking operators would be concerned about losing business since auto trips might decrease substantially. Low income individuals would be concerned about the regressiveness or unfairness of congestion pricing.

Public acceptability.

- As mentioned previously, extensive public objections could be expected toward any congestion pricing scheme. The public is strongly opposed to controls which restrict or prohibit the use of their private automobile as extensively as congestion pricing does.
- Differential toll fees are accepted by most toll facility users and have been met with only mild objections. Drive alone commuters view the reduced tolls as partial compensation for the inconvenience of ridesharing and since the reduced tolls do not adversely affect them, have voiced few objections.
- Raising tolls across the board for all users receives considerably more public objections because all commuters experience an increase. The drive alone commuter experiences the greatest impact since they must absorb the increase entirely by themselves while ridesharers can distribute the cost among members of their pool. The idea of raising the toll fee at all stimulates negative reactions.

Alternative Work Schedules

Description. Flexible work hours is a voluntary program that can be adopted by employers that permits employees some degree of flexibility in selecting arrival and departure times. The primary emphasis in this strategy is to reduce congestion to and from employment

centers, particularly CBD's, by spreading out the peak period (i.e., increasing the total duration of time during which commuting occurs and/or decreasing the percent of commuters traveling during the busiest period). Besides reduced congestion, flexible working hours allows employees to adjust their own hours to facilitate ridesharing with persons having different working hours but similar origin destination patterns. The program can also increase the quality of working life of employees by allowing more flexibility for family and leisure activities.

There are two basic alternative forms of variable work hours:

- o Staggered hours in which starting and quitting times are fixed but varied for either all employers or subsets of employees within an employment location.
- o Flexitime in which employees are permitted freedom to adjust their own working hours, within specified limits as long as the pay period total hours requirements are met.

In concept, flexitime has the potential of forming new ridesharing arrangements by matching together commuters who normally have different working hours. Even though behavioral studies and operational experiences have concluded that commuter's primary reasons for favoring flexible hours is so adjustments can be made to accommodate family and leisure activities more than for forming ridesharing arrangements. Operational experiences in Seattle, Washington, Reston, Virginia, Sacramento, California, and Albany, New York have reported increases in ridesharing arrangements as a result of flexitime.

A specialized form of work rescheduling is the shortened work week, with conversion from a 5 day/8 hours per day schedule to a 4 day/10 hours per day schedule. The principal objective of this strategy is to reduce total work trip travel demand per day and thus reduce congestion during peak periods. Implementation of 4 day work weeks can take on a variety of forms: (1) equal rotation of days worked from Monday to Friday; (2) equal rotation of days worked from Monday to Saturday; (3) one-half work Monday to Thursday, one-half work Tuesday to Friday; (4) one-half work Monday to Thursday, one-half work Wednesday to Saturday; and (5) one-third work Monday to Thursday, one-third work Tuesday to Friday, one-third work Wednesday to Saturday.

Implementation of 4 day work weeks is socially and politically more complex than variable work hours and its undertaking is dependent more on national policies and trends than on actions instituted by urban transportation agencies. For this reason 4 day work weeks will not be considered in further discussions.

Market identification. Flexible working hours is suitable to any sized city or employer with primary application directed to areas with severe congestion problems like the CBD or large employment centers. Measurable impacts are probably easier to accomplish in small and medium sized cities which have shorter congestion peaks than large cities where peak congestion periods may extend for more than an hour. Variable hours are also applicable to large single employers who experience short traffic peaks.

Staggered hours is generally applicable to large organizations with major subgroups that have interdependence in the nature of their work. Flexible work hours is applicable to most any sized work force where workers are less dependent upon others for the accomplishment of the work task. To date applications have been mainly directed to white collar workers although many light manufacturing industries in Switzerland and Germany are utilizing flexible hours.

Cities having overcrowded transit systems during peak periods may also be prime candidates since the spreading of commuter demand over longer periods could improve utilization of transit resources.

Implementation. Variable work hours can be implemented quickly by an employer once it is decided to adopt the policy. Planning and preparation can usually be completed in less than two months, and less than six months for larger employers. To develop an effective program in a CBD, one to two years would probably be necessary to gain the cooperation of a substantial proportion of employers and employees. The cost of developing such a program is minimal and can be combined with those of a ridesharing program since the major task is contacting employers and describing the program. The employers cost would also be minimal with planning and conversion to new timekeeping procedures being the main expenses.

From current experience with variable work hours, participation levels of CBD workers has ranged from 11 percent to 47 percent with an average of 28 percent (TRB, 1977). The number of participants as a percentage of total urban area employment ranged from 2 percent to 26

percent and averaged 5 percent. These figures suggest that a reasonable level of 15 to 20 percent of CBD employers or 4 to 5 percent of area wide employees can be expected to participate in a variable hours program.

In the early planning stages, transit operators should be consulted to coordinate changes in transit schedules and services to those of expected employee work times. Implementing variable hours without appropriate changes in the transit system will most likely cause the program to be ineffective in spreading out demand. Employee labor unions and organizations should also be contacted in early planning stages so that they can be properly informed about the program and avoid confusion and objections at the time of implementation.

Besides the benefits of variable work hours there are negative impacts associated with the programs. Many staggered work hour programs do not include enough individual flexibility in choice of hours which may cause dissolution of existing ridesharing arrangements and deter formation of new ones. Variable hours could decrease peak period congestion levels and consequently decrease transit ridership due to improved automobile travel. This impact may be more noticeable in small and medium sized cities where peak congestion periods are short and a flatting may decrease congestion and automobile trip times significantly. Variable hours may also increase total VMT due to the generation of more travel before and after work for shopping, recreation and business purposes. Variable working hours greatest success lies in flatting out peak period traffic volumes and allowing better utilization of existing highway and transit capacity. Of the two

forms of variable work hours, flexitime appears to have the greatest potential of forming new ridesharing for those truly interested.

Institutional/legal barriers. The primary institutional barrier is the reluctance of employers to adopt the program. Their primary reason is the costs involved and disruption to established employee practices. There are no apparent legal barriers prohibiting variable working hours.

Public acceptability. The public has been quite receptive to variable work hours. Both participating and nonparticipating members find little cause for objection. From behavioral studies the basic motivation behind favoring work schedule changes is the ability to introduce flexibility into family, leisure, and work activities. The desire to avoid traffic congestion is a contributing, but not a major factor.

CHAPTER IV

RIDESHARING ATTITUDES AND USER CHARACTERISTICS

A fundamental issue in developing and implementing effective ridesharing strategies is to address those reasons which stimulate as well as prevent participation in ridesharing. To many analysts, ridesharing's benefits are explicitly obvious (it saves on individual out-of-pocket costs and fuel, efficiently uses rider travel time, permits rider comfort and convenience in driving, frees up vehicles for use by other family members, reduces congestion, and gives personalized attention) and its detriments are felt to be so small, that planners often seem amazed that more individuals appear not to be aware of or inclined to engage in this form of travel. During the energy crisis of 1973-74, it appeared that interest was high toward ridesharing as measured by inquiries concerning carpool matching activities; but only a very small portion of the individuals expressing interest actually formed carpools, to say nothing of maintaining or continuing them after the crisis (Hartgen, 1977). This evidence is further substantiated by Wagner (1978) in his evaluation of carpool demonstration projects. Based upon this discussion and the view of several researchers that ridesharing is a psychosocial process, an understanding of an individual's attitude and behavior as related to ridesharing appears useful in effectively developing strategies which will encourage commuters to rideshare (Hood, 1977; Horowitz, 1976; Margolin, 1978).

In a review of recent research on ridesharing behavior, Hartgen (1977) states four hypotheses of why ridesharing is not very common: (1) carpoolers have unique trip and travel needs; (2) solo drivers lack information to form carpools; (3) attitudes of carpoolers are different from those of solo drivers; and (4) social processes involved in carpooling are difficult for solo drivers to overcome. Researchers have also concluded one of the primary factors influencing carpool formation and maintenance is the attitudinal disposition of riders toward carpools (in other words, how they feel about various psychological and social factors involved in carpooling), rather that "Objective" factors such as costs or travel time savings (Hartgen, 1977). Measurement of attitudes of both ridesharers and nonridesharers, in terms of travel characteristics, personal attributes, personal benefits, social benefits, and personal motives and goals provides identification of salient dimensions which are useful in defining market segments and ridesharing potential.

At present, researchers have not extensively pursued the subject of incorporating attitudinal and behavioral measures in the development and selection of ridesharing strategies. It is the purpose of this chapter to investigate beliefs toward ridesharing and emphasize how they can be utilized (latter in phases 3 thru 5) in the guidelines for market identification and strategy evaluation. The chapter will present findings from various studies on characteristics of ridesharers, and their reasons for ridesharing as well as investigating the reasons why solo drivers do not rideshare and the factors that would influence

them to switch to ridesharing. Characteristics and behavioral attitudes are also presented for commuters in Knoxville, Tennessee from recent surveys.

Characteristics of Carpoolers

The first question to address in distinguishing between carpoolers and solo drivers is that of demographic and travel characteristics. Several studies and program evaluations have recently addressed this point and are summarized in Table 4.1.

Tables 4.2 and 4.3 provide additional information on travel distance and sex of commuters from various cities. Table 4.2 identifies that carpoolers have longer commuting distances than solo drivers while Table 4.3 suggests that females comprise a greater proportion of ridesharers than solo drivers. This later characteristic does vary by city and suggests that the nature of the work force and their area of concentration may influence the proportion of female ridesharers.

In determining who rideshares an interesting factor is estimating the proportion of choice commuters who rideshare. If commuters have no other means of traveling to work besides transit and ridesharing, greater increases in ridesharing rates could be expected than if commuters were able to drive themselves. Tables 4.4 and 4.5 identify the extent of captive ridesharers in Knoxville by indicating that 12.3 percent do not have a drivers license and 9.4 percent do not have a vehicle available for their work trip. The number of vehicles per household in Knoxville for ridesharers is lower than solo drivers (2.0

TABLE 4.1 DEMOGRAPHIC AND TRAVEL CHARACTERISTICS OF CARPOOLERS

Study	Characteristics
Peat, Marwick, & Mitchell 1977[a] Survey of Chicago, Pittsburgh, Sacramento residents	Longer trip distance; 50-60% are 2 person pools; 21% are family pools; 40-55% of poolers share no expenses in the pool;
Margolin-Misch 1977[b] Panel discussion of Washington D.C. commuters	Longer Commute distance; Older than solo drivers; Regular working hours; High parking costs and reduced availability; 2 employed adults in household;
Harowitz - Sheth 1977[c] Survey of Chicago residents	Larger family; Larger car; Resided longer at residence; Employed longer at present site; Generally later in life cycle; Longer travel distance;
Voorhees 1974[d] Los Angeles freeway drivers	Employed at larger firms; Higher parking fee; Lower commute distance; Longer commute distance; Younger; Less flexible working hours;
Louisville 1977[e] Rideshare program evaluation	Slightly lower incomes; Younger; More females; 67% two person carpools; CBD and medical center employees had a higher carpooling rate than other areas;
Philadelphia 1977[f] Rideshare program evaluation	Similar age and income as solo drivers; Larger family size; Greater percentage are male; Fewer vehicles per household; Greater percentage of professionals carpool;

TABLE 4.1 (continued)

Study	Characteristics
Los Angeles 1979[g] Ridehsare program evaluation	Larger vehicle size; Similar age and income as solo drivers; Greater percentage are male; Longer commute distance; Slightly fewer vehicles per household;
Milwaukee 1977[h] Rideshare program	Longer commute distance; Greater percentage of females carpool than drive alone; Slightly younger, (49% under 35);

[a]Peat, Marwick, Mitchell and Co., "A Marketing Approach to Carpool Demand Analysis, Summary Report," July 1976.

[b]Margolin, J.B., and M.R. Misch, "Incentives and Disincentives for Ridesharing: A Behavioral Study," Federal Highway Administration, August 1978.

[c]Horowitz, A.D., and J.N. Sheth, "Ridesharing to Work: A Psychological Analysis," General Motors Research Laboratories, GMR-2216, August 1978.

[d]Voorhees, Alan M., and Associates, "Transportation Pooling," for U.S. DOT, Urban Mass Transportation Administration, January 1974.

[e]Kentuckiana Regional Planning and Development Agency, "1977 Telephone Survey For Full-Time Work Trips in the Louisville Metropolitan Area," Transportation Planning Division, August 1977.

[f]Delaware Valley Regional Planning Commission, Emergency Highway Energy Conservation Program, "Ridesharing in the DVRPC Region," June 1977.

[g]Shu, Jarvia, and L.J. Glazer, "Carpool Program Evaluation," Volume 2, Commuter Computer Carpool and Vanpool Ridesharing Program, May 1979.

[h]Schmitt, Robert P., "Carpooling in the Metropolitan Milwaukee Area," Southeastern Wisconsin Regional Planning Commission, Technical Report No. 20, March 1977.

TABLE 4.2 AVERAGE ONEWAY COMMUTER TRAVEL DISTANCE FOR SELECTED CITIES BY MODE (MILES)

Mode	Knoxville TN[a]	Los Angeles CA[b]	Houston TX[c]	San Diego CA[d]	Pittsburgh PA[e]	Chicago IL[f]	Sacramento CA[g]	Washington DC[h]
Drive Alone	8.2	19	12	14	6.5	11.2	9.4	13.1
Rideshare	11.0	23	19	17	8.6	16.3	9.8	17.4

[a]Surveys 1, 2, and 3 of Appendix B.

[b]Shu, Jarvia, and L.J. Glazer, "Carpool Program Evaluation," Volume 2, Commuter Computer Carpool and Vanpool Ridesharing Program, May 1979.

[c]Houston Carshare Program, "1978 Evaluation Report," Office of Public Transportation, City of Houston, February 1979.

[d]San Diego Regional Ridesharing Program, "Evaluation Report July 1978," July 1, 1978.

[e]Southwestern Pennsylvania Regional Planning Commission, "An Evaluation of the SPRPC Car Pool-Public Transit Program," September, 1975.

[f]Horowitz, A.D., and J.N. Sheth, "Ridesharing to Work: A Psychological Analysis," General Motors Research Laboratories, GMR-2216, August 20, 1976.

[g]Peat, Marwick, Mitchell and Co., "A Marketing Approach to Carpool Demand Analysis, Summary Report," July 1976.

[h]Margolin, J.B., and M.R. Misch, "Incentives and Disincentives for Ridesharing: A Behavioral Study," Federal Highway Administration, August 1978.

TABLE 4.3 SEX OF COMMUTERS FOR SELECTED CITIES BY MODE
(COLUMN PERCENTAGES)

Mode	Sex	Knoxville TN[a]	Los Angeles CA[b]	Pittsburgh PA[c]	Philadelphia PA[d]	Milwaukee WI[e]	Louisville KY[f]
Drive Alone	Male	52	64	70	65	65	65
	Female	48	36	30	35	35	35
Rideshare	Male	41	73	63	71	57	45
	Female	59	27	37	29	43	55

[a]Surveys 1, 2, 3, and 4 of Appendix B.

[b]Shu, Jarvia, and L.J. Glazer, "Carpool Program Evaluation," Volume 2, Commuter Computer Carpool and Vanpool Ridesharing Program, May 1979.

[c]Southwestern Pennsylvania Regional Planning Commission, "An Evaluation of the SPRPC Carpool - Public Transit Program," September, 1975.

[d]Delaware Valley Regional Planning Commission, Emergency Highway Energy Conservation Program, "Ride Sharing in the DVRPC Region," June 1977.

[e]Schmitt, Robert P., "Carpooling in the Metropolitan Milwaukee Area," Southeastern Wisconsin Regional Planning Commission, Technical Report No. 20, March 1977.

[f]Kentuckiana Regional Planning and Development Agency, "1977 Carpool Telephone Survey for Full-Time Work Trips in the Louisville Metropolitan Area," Transportation Planning Division, August 1977.

TABLE 4.4 LICENSED DRIVER BY MODE FOR KNOXVILLE COMMUTERS (ROW PERCENTAGES)

Mode	Yes	No
Drive Alone	99.2	0.8
Rideshare	87.7	12.3

Source: Surveys 1, 2, 3, and 4 of Appendix B.

TABLE 4.5 VEHICLE AVAILABILITY FOR WORK TRIP OF KNOXVILLE COMMUTERS (ROW PERCENTAGES)

Mode	Yes	No
Drive Alone	98.1	1.9
Rideshare	90.6	9.4

Source: Surveys 1, 3, and 4 of Appendix B.

to 2.3 respectively) which is similar to other areas. These values tend to indicate that the great majority of ridesharers are choice riders and rideshare for reasons other than necessity.

The age and income of Knoxville commuters by mode is presented in Tables 4.6 and 4.7 respectively and indicates that ridesharers tend to be younger with slightly lower incomes, which parallels characteristics in other areas. These findings should not be interpreted that ridesharing is primarily for younger commuters with lower incomes since in Knoxville one of the nation's most successful employer based ridesharing programs (Tennessee Valley Authority) is directed at higher income professional employees. The results rather indicate that a greater proportion of commuters who are younger with lower incomes rideshare. The occupations of Knoxville commuters by mode is presented in Table 4.8 and reveals that ridesharing is not associated with any one occupation but is present among various types. The higher percentage of ridesharers in the laborer category can be attributed to the nature of the Knoxville work force and the greater number of large manufacturing plants in the area. These findings do indicate that large firms employing lower income employees are prime candidates for ridesharing promotions.

A final characteristic of Knoxville commuters concerns employer size. Ridesharers tend to be employed by larger employers than solo drivers. The average employer size for Knoxville ridesharers is 1,383 employees to 1,022 for solo drivers.

TABLE 4.6 AGE OF KNOXVILLE COMMUTERS BY MODE
(ROW PERCENTAGES)

Mode	Age			
	Under 20	20 to 44	45 to 64	65 and Over
Drive Alone	2.3	63.9	32.2	1.6
Rideshare	6.4	57.0	35.3	1.2

Source: Surveys 1, 2, 3, and 4 of Appendix B.

TABLE 4.7 INCOME OF KNOXVILLE COMMUTERS BY MODE
(ROW PERCENTAGES)

Mode	Income				
	Less than $5,000	$5,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 to Over
Drive Alone	3.2	18.9	23.9	31.7	22.3
Rideshare	6.0	17.6	26.1	33.2	17.1

Source: Surveys 1, 2, 3, and 4 of Appendix B.

TABLE 4.8 OCCUPATION OF KNOXVILLE COMMUTERS BY MODE (PERCENTAGES)

Occupation	Mode	
	Drive Alone	Rideshare
Professional	18.3	19.6
Manager Administration	15.8	9.4
Sales	6.1	6.9
Craftsmen Foreman	7.7	8.2
Operator Nontransport	3.8	2.0
Transport Operators	1.9	0.8
Laborers	9.6	16.3
Farmers	0.1	0.0
Farm Laborers	1.0	0.0
Service Workers	11.1	9.0
Private Household Workers	0.5	0.0

Source: Surveys 1, 2, 3, and 4 of Appendix B.

These findings from Knoxville and those of other studies suggest that carpoolers differ from solo drivers on a number of dimensions:

- o they work at larger firms in high density locations;
- o they have more regularity in work hours;
- o they tend to have longer commute distances;
- o carpoolers tend to have larger families and larger cars;
- o they are similar in age and income;
- o they tend to have lived longer at their present residence and worked longer at their present employment site; and
- o carpoolers tend to have fewer vehicles per household.

Several studies have also investigated the differences between present and potential carpoolers. The initial conclusion is to assume that potential carpoolers are likely to be similar to present carpoolers, but that appears not to be the case. Margolin and Misch (1978) determined that while present carpoolers have some demographic differences from solo drivers, potential carpoolers do not. Most of their differences are attitudinal and emphasize the comfort and convenience of potential carpooling if an incentive such as express lanes were available. Horowitz and Sheth (1976) identified that potential carpoolers are likely to have resided at their residences a shorter period of time than most, which is opposite of characteristics of present carpoolers. Researchers agree that those demographic relationships that exist are extremely weak ones and, in fact, there are many standard variables in transportation (age, sex, income, vehicles per household, occupation) which have no or very little relationship whatsoever to whether or not an individual rideshares. The studies also suggest that

some differences exist between present and potential carpoolers, which make it somewhat difficult to extrapolate observations from present carpoolers to determine under what conditions additional commuters would carpool. Even with these weak relationships, some characteristics have been identified to assist planners in identifying market segments for ridesharing and suggest that careful market analysis be conducted.

Attitudinal Characteristics

From the preceding discussion, it was suggested that one of the primary factors in influencing rideshare formation is the attitudinal disposition of drivers toward ridesharing. Since demographic relationships are weak, additional insight is needed to identify potential ridesharers. Until recently, few research efforts have investigated behavioral attitudes toward ridesharing in an attempt to better understand why individuals rideshare. Early and less comprehensive studies have taken verbatim responses from individuals as descriptors of their true feelings. Recent more comprehensive investigations have taken a greater in-depth approach to identifying attitudes (Deuka, 1977; Horowitz, 1976; Margolin, 1978). Table 4.9 summarizes factors influencing rideshare formation from recent behavioral studies and rideshare program evaluations.

Examining Table 4.9, it is revealed that the primary reasons motivating rideshare arrangements are saving money, relief from driving, and energy conservation. These responses are primarily those of current ridesharers and in most cases, are reasons commonly cited as

TABLE 4.9 FACTORS INFLUENCING RIDESHARING

Study	Primary Factors	Secondary Factors
Milwaukee 1977[a] Household survey	+Save money +Help a friend -Changing work times and locations -No one to carpool with -Need use of auto at work	+Companionship +Energy conservation
San Diego 1978[b] Rideshare program evaluation	+Save money	
Boston 1976[c] Rideshare program evaluation	+Cost savings +Energy crisis +Relief from driving -Reduced independency and mobility -Irregular work hours -Need vehicle during the day	+Make vehicle available for someone else +Companionship -Inconvenience -Depend on others -Increased travel time
Raleigh, NC 1976[d] Rideshare program evaluation	-Irregular or unusual hours -Need vehicle after work -Work overtime	
Connecticut 1977[e] Rideshare program evaluation	+Save money +Conserve energy +Environmental considerations +Dislike driving alone -Irregular hours -Need vehicle at work	
Houston 1978[f] Rideshare program evaluation	+Cost savings +Convenience	
Portland 1978[g] Carpool attitude and awareness study	+Saves money +Avoids commuting hassles -Don't like relying on others -Increased travel time	
Margolin - Misch 1977[h] panel discussion of Washington, D.C. residents	+Cost savings -Less convenient -Increased travel time (having to wait on others) -Social aspects (riding with strangers, smoking)	+Parking privileges +Preferential lanes for carpools
Dobson & Tischer 1977[i] Survey of Los Angeles CBD commuters	+Carpool comfort +Carpool cost -Convenience of bus -Having to wait in traffic -Flexible scheduling	

TABLE 4.9 (Continued)

Study	Primary Factors	Secondary Factors
Dueker 1974[j] 3 Iowa City firms	+Save money +Reduce pollution +Proximity of other riders -Reduced Independence -Inconvenient -Need vehicle during or after work	
Los Angeles, 1979[k] Carpool program evaluation	+Save money on gasoline +Save wear on car -Irregular work hours -Reduced independence	+Avoid driving stress +Save energy -Need vehicle at work -Increased travel time
Horowitz - Sheth[l] 1977, 1975 survey of Chicago residents	-Increased travel time -Less convenient	
Bruggeman 1977[m] Survey of Chicago, Pittsburg, Sacramento residents	+Reduce pollution -Waiting to pick someone up -Waiting to be picked up -Not having to adjust schedule -Having to depend on others -Lack ability to drive oneself -Need vehicle during the day	+CBD and major employment centers +Large employers (greater than 200)
Wiersig 1977[n] Survey of Knoxville area vanpoolers	+Avoid driving every day +Save money +Increased availability and reduced cost of parking +Conserves gasoline -Not able to leave work anytime	+Makes vehicle available for someone else -Cannot work overtime

[a]Schmitt, Robert P., "Carpooling in the Metropolitan Milwaukee Area," Southeastern Wisconsin Regional Planning Commission, Technical Report No. 20, March 1977.

[b]San Diego Regional Ridesharing Program, "Evaluation Report July 1978," July 1, 1978.

[c]Massachusetts Department of Public Works, "Ride-Sharing Program: Evaluation Report," February 1978.

[d]City of Raleigh Carpool Program, "Interim Evaluation Report," prepared by the Raleigh Planning Department, November 1976.

[e]Connecticut Department of Transportation, "Connecticut Commuter Carpool Program," Bureau of Planning and Research, October 1977.

[f]Houston Carshare Program, "1978 Evaluation Report," Office of Public Transportation, City of Houston, February 1979.

TABLE 4.9 (Continued)

[g]TRI-MET, "Carpool Attitude and Awareness Study," Portland, Oregon, January 1979.

[h]Margolin, J.B.,and M.R. Misch, "Incentives and Disincentives for Ridesharing: A Behavioral Study," Federal Highway Administration, August 1978.

[i]Dobson, R., and M.L. Tischer, "A Comparative Analysis of Determinants for Central Business District Worker Mode Choices," presented at the 1977 Transportation Research Board Meeting.

[j]Dueker, K.J., et al., "Ridesharing: Psychological Factors," Transportation Engineering Journal, ASCE, November 1977, pp. 685-692.

[k]Shu, Jarvia, and L.J. Glazer, "Carpool Program Evaluation," Volume 2, Commuter Computer Carpool and Vanpool Ridesharing Program, May 1979.

[l]Horowitz, A.D., and J.N. Sheth, "Ridesharing to Work: A Psychological Analysis," General Motors Research Laboratories, GMR-2216, August 20, 1976.

[m]Peat, Marwick, Mitchell and Co., "A Maketing Approach to Carpool Demand Analysis, Summary Report," July 1976.

[n]Wiersig, D.W., and F.J. Wegmann, "Vanpooling--A New Dimension in Urban Transportation: Results from Two Operational Programs," presented at 57th Annual Meeting of the Transportation Research Board, January 1978.

advantages of ridesharing. Table 4.9 also summarizes negative factors of ridesharing by both ridesharers and nonridesharers.

In general, commuters view ridesharing as being less convenient than driving alone and feel it reduces their independence and mobility. A common response for not ridesharing by solo drivers is their irregular work hours or work locations and the need of their vehicle at work. In most instances, it would be difficult to control these former two reasons, but carefully planned promotional campaigns could ease the fear of reduced mobility and convenience. In most instances the actual reduction in mobility and convenience is far less than that perceived by solo drivers. Emphasizing the convenience aspects of ridesharing thus appears to be a prime strategy since inconvenience is a major reason for not ridesharing.

Tables 4.10 and 4.11 present primary and secondary likes and dislikes of ridesharing by mode for Knoxville commuters. The results indicate that cost savings and relief from driving are the primary positive factors of ridesharing for both ridesharers and nonridesharers. Secondary factors are companionship and relief from driving. Both groups appear to feel similarly toward ridesharing except, that ridesharers experience less difficulty in parking and fewer perceive ridesharing as an energy conservation measure. Examining dislikes, it is revealed that the primary deterrents or dissatisfactions of ridesharing are schedule inconveniences and reduction in independence and mobility. Ridesharers view both of these factors as being less important than solo drivers, while 43 percent had no dislike toward ridesharing. Secondary dislikes are again reduced independence and the lack

TABLE 4.10 LIKES OF RIDESHARING FOR KNOXVILLE COMMUTERS BY MODE (COLUMN PERCENTAGES)

Factors	Primary Responses		Secondary Responses	
	Solo Drivers	Ridesharers	Solo Drivers	Ridesharers
Cost savings	75.3	65.0	4.5	1.8
Relief from driving	11.0	21.3	24.6	25.5
Make vehicle available for others	1.0	0	4.0	3.6
Delays buying another vehicle	1.0	0	6.5	9.1
Solves parking problems	1.7	2.5	7.5	18.2
Companionship	5.1	10.0	25.6	27.3
Time savings	0	1.3	2.5	5.5
Energy conservation	4.8	0	24.1	9.1

Source: Survey 1 and 4 of Appendix B.

TABLE 4.11 DISLIKES OF RIDESHARING FOR KNOXVILLE COMMUTERS BY MODE (COLUMN PERCENTAGES)

	Primary Responses		Secondary Responses	
Factors	Solo Drivers	Ridesharers	Solo Drivers	Ridesharers
Schedule inconvenience	47.4	36.4	3.9	0
Distance inconvenience	1.5	1.1	5.5	0
Increased travel time	2.8	0	8.3	9.5
Reduced privacy	2.0	3.4	7.7	9.5
Increased expense	0.2	0	0.5	4.8
Reduced independence and mobility	12.8	10.2	44.8	42.9
Cannot use vehicle during the day	0.9	1.1	10.5	19.0
Reduced comfort	1.1	1.1	2.8	9.5
Harder to work overtime	0.4	1.1	7.7	4.8
Personality conflicts	2.0	2.3	8.3	0
No dislikes	28.9	43.2	--	--

Source: Survey 1 and 4 of Appendix B

of a vehicle to use during the day. It is important to note that solo drivers did not consider increased travel distance or time, or reduced privacy and comfort as being deterrents to ridesharing. Thus, stressing these factors in ridesharing strategies would be less productive since few consider it important in their decision to rideshare. Tables 4.12 through 4.15 present similar results of likes and dislikes for Knoxville commuters from different survey instruments.

Several ridesharing programs determined that computer match lists were seldom used since commuters were reluctant to contact or make rideshare arrangements with strangers. This seems to suggest that unless additional personalized efforts are incorporated in the matching process, little use will be made of match lists. Several programs have been suggested to increase the use of match lists. The first entails the use of a coordinator, usually the ridesharing agency, which calls prospective ridesharers and attempts to "break the ice" and introduce commuters. In Knoxville this technique has worked extremely well in screening out those not interested in ridesharing and introducing interested parties through use of telephone conference calls. Another technique suggested by Margolin and Misch (1978) employs a neighborhood coordinator who brings together potential poolers through informal neighborhood meetings. Thus, allowing commuters to meet and acquaint themselves with one another prior to arranging a pool.

The previously discussed results suggest that attitudinal intentions toward ridesharing are more complex than simple verbatim responses. Voorhees, (1973) in a study of Los Angeles drivers, suggested

TABLE 4.12 LIKES OF RIDESHARING FOR KNOXVILLE COMMUTERS BY MODE FROM SURVEY 2 (COLUMN PERCENTAGES)

Factors	Solo Drivers	Ridesharers
Cost savings	49.3	35.7
Energy conservation	21.7	11.0
Relief from driving	15.7	19.9
Companionship	5.7	15.1
Solves parking problems	4.3	7.5
Dependability	1.0	4.8
Makes vehicle available for others	1.3	2.7
Time savings	0.7	2.1
Avoid buying another vehicle	0.3	1.4

Source: Survey 2 of Appendix B.

TABLE 4.13 DISLIKES OF RIDESHARING FOR KNOXVILLE COMMUTERS BY MODE FROM SURVEY 2 (COLUMN PERCENTAGES)

Factors	Solo Drivers	Ridesharers
Schedule inconvenience	33.6	17.1
Reduced independence and mobility	23.5	27.6
Cannot use vehicle during the day	11.9	10.5
Harder to work overtime	11.1	10.5
Increased travel time	4.7	6.6
Distance inconvenience	4.2	6.6
Reduced privacy	3.2	6.6
Have to depend on others	2.5	2.6
Increased responsibility	2.0	3.9
Reduced comfort	2.5	6.6
Disagreements with other members	1.0	1.3
Increased expense	0	0

Source: Survey 2 of Appendix B.

TABLE 4.14 REASONS FOR RIDESHARING KNOXVILLE COMMUTERS

Reason	Percent
Conserve gasoline	35.6
Save money	33.6
Avoid driving every day	25.8
Knew other members at work	11.1
Make vehicle available for someone else	9.0
Knew other members from neighborhood	7.4
Availability and cost of parking	4.3
Avoid buying a second car	3.2
More dependable than regular bus	2.8
Do not own a car	1.2

Source: Survey 5 of Appendix B.

TABLE 4.15 REASONS FOR NOT RIDESHARING KNOXVILLE COMMUTERS

Reason	Percent
Inconvenient	22.9
Would rather drive alone	19.1
Irregular hours	10.9
Work overtime	9.2
Need vehicle at work	8.2
Live too far away from each other	7.0
Other riders work at different times	5.5
Other riders did not want to form pool	1.6
Did not know other riders well enough	1.2
Did not like personalities of other riders	1.2

Source: Survey 5 of Appendix B

that negative financial considerations were surrogates for a large number of "hidden" negative incentives concerning the individual's desire for self reliance, independence from others, and privacy. Kirby (1974) also found inflexibility of schedule and lack of privacy to be prime negative deterrents to carpool formation. In addition, he found that schedule reliability and the ability to do things while traveling as well as safety from crime to be positive incentives.

In a more recent study in 1975 of Chicago residents, Horowitz and Sheth (1976) found the inconvenience of carpooling to be a primary deterrent to its formation. They determined that since the attitudes of carpoolers toward ridesharing are very positive in regards to convenience, reliability, and comfort, that this information could be communicated to solo drivers for the promotion of ridesharing. The most significant result they concluded from their study is that the intention to carpool and the affect toward ridesharing are related to the perceived negative evaluations rather than to the positive aspects. Thus, suggesting that ridesharing campaigns should address the perceived negative evaluations rather than positive ones, which is opposite to present carpooling promotional campaigns such as "Pool It" and "Double up America" which have emphasized how individuals could benefit if they changed their commuting patterns.

Peat, Marwick and Mitchell (1976a), in their study for the Federal Energy Administration, found a strong deterrent to carpooling to be the inconvenience generated by waiting to pick up other people or be picked up, required schedule adjustments and the idea of having to depend on someone else.

The most recent and comprehensive study of ridesharing attitudes was conducted of suburban residents in the Washington, D.C. area by Margolin and Misch (1978). They discovered that interpersonal factors were the most important considerations in carpool formation. Social aspects, particularly the individual's desire to maintain independence and control over their environment, personality clashes, and the general "hassle" caused by waiting for others and inconveniences were the primary deterrents to carpooling. In their study, 86 percent of the respondents indicated that they would prefer to meet the individuals first, rather than working through computer matching methods.

This review of recent studies suggests that economic pressures are not the primary motivating factors for ridesharing but rather perceptions toward carpool mates and the general inconvenience and hassles of ridesharing are weighted more heavily in mode selection. In the case of direct financial incentives by employers, economic considerations may outweight these other social issues, but generally the monetary savings of forming a carpool and sharing the cost are not great enough to influence decisions. These studies indicate that solo drivers perceive the inconveniences of ridesharing far greater than what they actually are and, consequently, are reluctant to switch modes. This reluctance to contact potential poolers appears to stem from a strong desire not to rideshare and, in turn, reinforces the negative feelings toward ridesharing. Through these findings, it appears that strategies which attempt to overcome these perceptions will be most significant in causing solo drivers to switch modes.

Thus, promotional campaigns which stress the conveniences of ridesharing and convey the positive attributes, coupled with more personalized matching techniques, should be given primary emphasis. If commuters are willing to continue to pay for the high price of driving alone by absorbing increases in tolls or parking costs, implementation of strategies that stress these issues will produce little shifts toward ridesharing. Under these conditions project finances might be better utilized in providing more personalized matching services that attempt to bring commuters together.

Strategies to Increase Ridesharing

The preceding section suggests several strategies which could be utilized to increase ridesharing. Also identified was the fact that many current or previously proposed strategies are not likely to have much effect in increasing ridesharing since they fail to address the primary reasons as to why commuters do not rideshare. Several of the previously mentioned studies and program evaluations addressed the question of what kind of strategies, both positive and negaitve, could be implemented to increase ridesharing. Table 4.16 summarizes these findings and indicates that in several program evaluations, solo drivers indicated that they would rideshare if their work hours were more regular, but as previously mentioned, it would be difficult to control work hours or shifts.

The studies by Margolin and Misch (1978) stress the need for more "face-to-face" meetings of potential poolers and the deemphasis of computer match lists by themselves. Horowitz and Sheth (1976) concur

TABLE 4.16 STRATEGIES OR FACTORS TO INCREASE RIDESHARING

Study	Strategies or Factors	Weak Strategies
Los Angeles 1979[a] Rideshare program evaluation	If work hours were regular If computer matches were good Knew more about carpool partners Received assistance in actually calling carpool partners	
Boston 1978[b] Rideshare program evaluation	Flexible working hours Encourage reduction in car insurance for carpoolers Reduced parking fees for carpoolers	Preferential parking
Raleigh 1976[c] Rideshare program evaluation	Preferential parking Reduced parking fees for carpoolers	
Milwaukee 1977[d] Household survey	Change in work hours Find a carpool partner Change in work location No longer need vehicle at work	
Levin 1979[e] Iowa City residents	Personal contact with potential rideshares before pooling	
Horowitz & Sheth 1977[f]	Can do other things while traveling to work (read, sleep) Emphasize convenience Assist in carpool formation (meeting of poolers at work)	Public interest appeals (energy, congestion, pollution) Economic factors
Dobson & Tischer 1977[g]	De-emphasis of flexible schedule & not having to wait in traffic Preferential parking and travel lanes Highlight positive attributes -safety -inexpensive -lack of crowding	
Margolin & Misch 1977[h]	Stress interpersonal/social needs/affiliation Provide face to face meeting of poolers either at work site or through residential coordinators Residential coordinators can: -provide personal introduction -overcome reluctance -show how to set up rules, etc. Noncomputerized systems (personalized) Carpool booklets and fimilarization Careful market segmentation Preferential lanes	Cost Matching systems (too impersonal)
Bruggeman 1977[i]	Effectiveness of strategies depends on the site of the affected market segment. (parking surcharges and higher tolls effect few commuters) Gas rationing had largest effect Parking surcharge Gas surcharge Travel time changes	Improved matching techniques Reduced parking rates for pools Rebates Improved midday transportation

TABLE 4.16 (continued)

[a]Shu, Jarvia, and L.J. Glazer, "Carpool Program Evaluation," Volume 2, Commuter Computer Carpool and Vanpool Ridesharing Program, May 1979.

[b]Massachusetts Department of Public Works, "Ride-Sharing Program: Evaluation Report," February 1978.

[c]City of Raleigh Carpool Program, "Interim Evaluation Report," prepared by the Raleigh Planning Department, November 1976.

[d]Schmitt, Robert P., "Carpooling in the Metropolitan Milwaukee Area," Southeastern Wisconsin Regional Planning Commission, Technical Report No. 20, March 1977.

[e]Levin, Irwin P., "Evaluation of Interpersonal Influences in the Formation and Promotion of Carpools," Paper submitted for presentation at the Meetings of the Transportation Research Board, Washington, D.C., January 1979.

[f]Horowitz, A.D., and J.N. Sheth, "Ridesharing to Work: A Psychological Analysis," General Motors Research Laboratories, GMR-2216, August 20, 1976.

[g]Dobson R., and M.L. Tischer, "A Comparative Analysis of Determinants for Central Business District Worker Mode Choices," presentation at the 1977 Transportation Research Board Meeting.

[h]Margolin, J.B., and M.R., Misch, "Incentives and Disincentives for Ridesharing: A Behavioral Study," Federal Highway Administration, August 1978.

[i]Peat, Marwick, Mitchell and Co., "A Marketing Approach to Carpool Demand Analysis, Summary Report," July 1976.

with these findings by suggesting informal "get acquainted" meetings for potential poolers and emphasis on convenience in promotional campaigns. Dobson and Tischer (1977) are more specific in their suggestions by identifying preferential parking and travel lanes as positive strategies to increase ridesharing. Peat, Marwick and Mitchell (1976a) in their studies determined that disincentives (gas rationing) would be most significant in increasing the number of carpools.

These results suggest that community wide matching programs that require commuters to make the intial contact by themselves, will be less successful then face-to-face meetings of potential poolers. Matching strategies which provide this type of service like telephone conference calls in Knoxville, Tennessee, or programs which are directed at large concentrated market segments have greater potential since initial introductions are made by a third party or a closer relationship may exist by the mere presence of working for the same employer or a neighboring one. Concentrating efforts to selected areas also makes it easier to set up informal "get acquainted" meetings of potential ridesharers at the worksite or neighborhood community facilities.

An additional important finding from these studies is that in many cases, respondents suggested incentives that address area specific issues. In the case of Boston, commuters identified a reduction in insurance rates as being a motivating factor (Massachusetts, 1978). Considering the high insurance premiums of the Boston area, this strategy appears to address an issue which would draw considerable

attention. Likewise, preferential lanes in Los Angeles and Washington, D.C., are highly visible, and as a result of excessive traffic congestion should draw considerable attention. Thus, it appears that strategies should attempt to be specific and relate to characteristics and situations of the market segment under consideration. Strategies must also attempt to impact the largest market segment possible. Preferential parking or surcharges are powerful strategies in areas where parking is in short supply, but in most communities a low proportion of all commuters are faced with parking problems. Consequently, these strategies would produce little community wide effect in reducing VMT.

Summary

Through distinguishing the differences between solo drivers and ridesharers in terms of trip and trip maker characteristics, potential market segments can be more readily identified. From these differences in characteristics it was determined that ridesharing is more predominate at large firms in high density locations, among individuals with longer commute distances, households with fewer vehicles, workers with more regularity in work hours, and among large families. targeting ridesharing strategies to these market segments should increase the potential for stimulating new ridesharing.

Through examining attitudes of commuters toward ridesharing, an additional insight is gained as to those reasons which stimulate as well as prevent individuals from participating in ridesharing arrangements. From past attitudinal studies it was concluded that economic pressures are not the primary motivating factors for ridesharing but

rather preceptions toward carpool mates and the general inconvenience and hassles of ridesharing we weighted more heavily in mode selection. Also identified was the fact that attitudes toward local specific issues can play a significant role in stimulating ridesharing. In many instances commuters may consider issues such as parking problems or high auto insurance premiums as reasons for considering to rideshare. If ridesharing strategies addressed these issues through reduced parking fees, perferential parking or reduced insurance premiums for ridesharers, many commuters may be influenced to rideshare since these actions affect issues which commuters are most concerned about.

In undertaking a ridesharing program, planners should investigate commuter's attitudes toward travel and ridesharing. Through general responses concerning travel conditions, local issues which commuters are concerned about can be identified and if possible ridesharing strategies may be developed which address these issues. For example, a general comment of commuters might be that parking rates are extremely high in the CBD. In this situation a parking management strategy which provides reduced parking rates for ridesharers may be an action which would influence commuters to rideshare.

Attitudes toward ridesharing and local travel conditions can be obtained from informal comments made by commuters, letters to the editor in local newspapers, and citizen comments at public meetings. In addition to these methods a survey of local commuters could be undertaken to identify attitudes.

In addition to determining local attitudes and issues, research has indicated that commuters are reluctant to meet other potential ridesharers

on their own and for this reason make no further effort in forming a ridesharing arrangement other than obtaining a list of names. To help overcome this barrier, it is suggested that more personalized matching services be initiated that attempt to "break the ice" by introducing potential poolers. This could be accomplished through the use of employer or neighborhood corrdinators that arrange informal get togethers of commuters where introductions are more easily made. Another technique at introducing commuters which has worked well in Knoxville, Tennessee, is that of conference telephone calls initiated by the ridesharing coordination between potential poolers.

Through utilizing the research results presented in this chapter and incorporating local attitudes in the identification and selection of strategies the overall scope and effectiveness of the ridesharing program should improve.

CHAPTER V

SUPPLY MODELS

An important element in developing and selecting ridesharing strategies is to determine the number of commuters needed to participate in ridesharing to achieve a desired level of travel reduction. Being able to estimate the necessary magnitude in ridesharing participation is beneficial in the early planning stages to identify whether desired reduction levels in VMT and energy usage are feasible. Matching these supply estimates, which comprise Step 2 of the planning guidelines later with demand estimates of Step 5, provides an assessment of the ability to reach desired reduction levels and the resulting level of program intensity. Determining participation levels identifies the degree of effort necessary to reach desired reduction levels and provides a means of assessing whether to continue with these reduction levels and level of intensity or adjust target reduction values to coincide with acceptable intensity and funding levels. To accommodate this need a set of supply models have been developed which estimate the number of commuters needed to participate in ridesharing to achieve given levels of reduction in vehicle miles of travel (VMT), energy consumption, and parking demand. Separate figures have been developed for each of these reductions for both carpools and vanpools. These modal breakdowns enable planners to develop an optium balance in ridesharing modes given the travel characteristics of their community. The use of these models also enables an assessment of the practicality

of reduction levels in light of the number of commuters needed to participate and the resulting level of program intensity to accomplish these goals.

Model Considerations

In developing the supply models numerous considerations must be given to vehicle load factors and travel distances in order to make even rough estimates of the potential of ridesharing. Factors which have been considered in the models include: prior mode of new carpoolers; vehicle occupancy of new carpools; home-to-work trip length; frequency of carpooling; trip circuity of new carpools; use of vehicles left at home during the work day; miles of travel generated by persons meeting at pickup points; and the size of the vehicle formerly driven by poolers. A discussion of these considerations and their impact in estimating participation levels follows.

Prior mode. In switching to a ridesharing mode, it can not be assumed that all new poolers are diverted from single occupant vehicles, since many may come from existing carpools and transit. Accounting for these other diversions significantly decreases the expected reduction in VMT since prior mode determines the number of vehicles that are no longer driven to work. For example, if 25 commuters switch to ridesharing and all 25 formerly drove alone, previous vehicle occupancy would be 1.0 and 25 vehicles would no longer be driven to work. On the other hand, say five of these 25 commuters formly carpooled in five different carpools of two persons each. The previous occupancy would be 1.2 and only 21 vehicles would be removed,

a 16 percent decrease from the initial case. From a recent evaluation of FHWA carpool demonstration projects, it was reported that 20 percent of new carpoolers were diverted from other than single occupant vehicles with a vehicle occupancy of 1.2 (Wagner, 1978). In the case of vanpooling, a greater percentage of new riders are diverted from carpools than single occupant vehicles because of the longer trip distances associated with vanpooling and a greater incentive by commuters to previously form carpools. Table 5.1 lists the previous mode of van riders for selected programs which results in an average previous vehicle occupancy of 1.79.

Vehicle occupancy of new pools. The formation of new pools results in a number of vehicles still being used for commuting to work. In most instances single occupant vehicles have added riders and are now being used as pooling vehicles. In determining energy reductions, the number of vehicles that are still being driven to work, especially those used for commuting, must be accounted for to obtain accurate reduction values. This is accomplished by determining the vehicle occupancy of new pools and dividing it by the total number of new poolers. This number inturn is subtracted from the earlier estimate of the number of vehicles no longer driven to work and yields the actual number of vehicles removed. The FHWA carpool evaluation found new carpool occupancy to average 2.85 persons per car (Wagner, 1978). Vanpool occupancy averages approximately 11 riders per van for 12 passenger vans.

TABLE 5.1 PREVIOUS MODE BEFORE VANPOOLING
(COLUMN PERCENTAGES)

Mode	3-M Company[a]	Conoco[b]	Michigan DOT[c]	Knoxville Commuter Pool[d]	Tennessee Valley Authority[e]	Aerospace[f]
Drive Alone	44	42	49	38	45	40
Carpool	39	55	49	59	36	51
Other	17	3	2	3	19	9
Vehicle Occupancy	1.70	1.93	1.77	1.91	1.67	1.84

[a]Owens, Robert D., and H. L. Sever, "The 3-M Commute-A-Van Program: Status Report May 1974," 3M Company, St. Paul, Minnesota, May 1974.

[b]Continental Oil Company, "Van Pooling: A Commuting Alternative That Works," Houston, Texas, August 1978.

[c]Michigan Department of State Highway and Transportation, "Michigan State Employee Vanpool Program Survey Results," Bureau of Transportation Planning, April 1978.

[d]Wiersig, D. W., and F. J. Wegmann, "Vanpooling--A New Dimension in Urban Transportation: Results from Two Operational Programs," paper presented at the 57th Annual Meeting of the Transportation Research Board, January 1978, p. 8.

[e]Ibid., p. 8.

[f]Johnson, Chris, and A. K. Sen, "Van Pool Planning Manual," U.S. DOT, Office of University Research, DOT-RSPA-DPB-50-78-10, November 1977.

Frequency of ridesharing. The number of days each pooler participates in a pool is an important consideration since additional mileage is generated when riders drive to work by themselves. This situation happens frequently when riders need their vehicle during or after work. At some companies where employees must be away from the office during the week a lower frequency of pooling can be anticipated since they may drive alone these days or do not make the trip if business carries them out of town. If commuters rideshare only three or four days per week, a decrease in the expected energy reduction resulting from pooling may occur which requires that additional commuters must participate in pooling to achieve the desired reductions. Table 5.2 shows the frequency of carpooling for those who carpool five days per week in selected cities. From these reportings it appears reasonable to estimate that on the average 84 percent of carpoolers participate in a carpool five days per week. The frequency of vanpooling has not been reported in rider evaluations, but it appears reasonable to assume that the rate is higher than carpooling because riders purchase a seat on a subscription basis rather than paying for the number of days they actually ride. Based on this information and conversations with Knoxville vanpoolers, it is assumed that 95 percent of vanpoolers participate five days per week.

Trip circuity of pools. In most instances carpool trips tend to be longer than single occupant trips because of the trip circuity of picking riders up at their home or designated meeting points. Estimates

TABLE 5.2 PERCENT OF CARPOOLERS WHO CARPOOL FIVE DAYS PER WEEK

City	Carpoolers Who Pool Five Days Per Week
Milwaukee[a]	82.1
Boston[b]	73
Louisville[c]	86.5
Houston[d]	93
Knoxville[e]	83.6

[a]Schmitt, Robert P., "Carpooling in the Metropolitan Milwaukee Area," Southeastern Wisconsin Regional Planning Commission, March 1977.

[b]Massachusetts Department of Public Works, "Commonwealth of Massachusetts Ride-Sharing Program Evaluation Report," Boston, Massachusetts, February 1978.

[c]Kentuckiana Regional Planning and Development Agency, "1977 Carpool Telephone Survey for Full-Time Work Trips in the Louisville Metropolitan Area," August 1977.

[d]The City of Houston Office of Public Transportation, "The Houston Carshare Program: 1977 Annual Report."

[e]Wiersig, D. W., and F. J. Wegmann, "Vanpooling - A New Dimension in Urban Transportation: Results from Two Operational Programs," paper presented at the 57th Annual Meeting of the Transportation Research Board, January 1978.

of the added distance are not well documented because they have not been included in program evaluations and like most distance values, are difficult for riders to estimate. Cambridge Systematics, Inc. analyzed several data sources and estimated trip circuity at one-half mile per person per trip for those carpooling (FEA, 1976b). Trip circuity for vanpooling is not reported in evaluations but is assumed to be longer at .75 miles per rider per trip because of the greater dispersion of vanpoolers.

Vehicle left at home. Another distance factor which has received considerable attention is the amount of travel that takes place by vehicles that are left at home by carpoolers. Travel which takes place during the day by these vehicles can be of two types, either additional new travel generated by other family members or existing travel for shopping etc., that has been diverted to the midday because a vehicle is now available. The ability to distinguish between new and diverted travel and the difficulty in its estimation by poolers has lead many evaluators to question its reliability. For this reason and the fact that accounting for this additional mileage would be only slight when compared to the many other uncertainties in vehicle occupancy estimates, adjustments have not been made in the supply models to compensate for this additional mileage.

Travel to pick-up points. A distance factor also to be considered is the amount of travel generated by commuters who arrange to meet their pool at designated pickup points. In these instances a

portion of the trip is being made by one or more single occupant vehicles rather than the pooling vehicle and consequently this practice generates additional mileage that is not considered in the trip distance of the pooling vehicle. In the case of carpools this additional trip distance has not been reported in evaluation studies and consequently is not considered in the supply models. Vanpool evaluations on the other hand have investigated this area since a greater proportion of riders meet at designated points because of the increase in travel time that would result if each rider was pickedup at home. Table 5.3 lists the percent of van riders who meet at pickup points and the associated average distance from their home to the meeting point for various vanpool programs. From these reportings, an average of 43.5 percent of the riders meet at a pickup point, 3.23 miles from their home.

Size of vehicle formerly driven by ridesharers. A final factor to be considered is the size of the vehicle that new poolers formerly drove. This plays an important role when determining energy reductions because car size is very sensitive to the fuel usage rate. When determining energy reductions a more reliable estimate is possible if former vehicle size is considered. Since data has not been reported on former vehicle size, the most appropriate estimate is to assume that all new poolers formerly drove standard and compact cars. It seems reasonable to assume that few new poolers would be diverted from subcompact cars since the cost savings would be relatively small. The percent distribution of the two sizes would then be determined from

TABLE 5.3 DISTANCE AND PERCENT OF VANPOOLERS WHO MEET AT PICKUP POINTS

City	Percent Meeting at Pickup Points	Miles From Home to Pickup Point
Michigan DOT[a]	32.6	3.6
Knoxville Commuter Pool[b]	50.3	2.9
Tennessee Valley Authority[c]	47.7	3.2

[a]Michigan Department of State Highway and Transportation, "Michigan State Employee Vanpool Program Survey Results," Bureau of Transportation Planning, April 1978.

[b]Wiersig, D. W. and F. J. Wegmann, "Vanpooling - A New Dimension in Urban Transportation: Results from Two Operational Programs," paper presented at the 57th Annual Meeting of the Transportation Research Board, January 1978, p. 13.

[c]Ibid., p. 13.

their proportion of the vehicle mix in the area. For example if standard and compact cars account for 45 and 35 percent of the vehicle mix respectively, it would be assumed that 56 percent formerly drove standard size cars and 44 percent drove compacts. Information on the mix of vehicle sizes in an area may be available from the state motor vehicle registration department, the state energy office or travel surveys conducted in the area. If this information is not available, it is best to assume that poolers formerly drove compact cars. Fuel usage rates as reported from the Department of Transportation are 14 miles per gallon (mpg) for standard size cars and 16 mpg for compacts.

Model Formulation

Formulation of the supply models is relatively straightforward and similar for both carpools and vanpools. To best illustrate the general procedure of the models a numerical example is first presented, followed by the algebraic formulation.

Numberical example. Consider a situation where a reduction in daily VMT is desired of 500 miles and the average round trip commute distance is 20 miles. The first step is to account for trip circuity of carpoolers, one mile and subtract this distance from the round trip distance. Dividing the desired VMT reduction of 500 miles by the corrected 19 mile trip distance equals 26.3 which is the number of single occupant driver trips that must be discontinued. Since not all new carpoolers are drive alone commuters, this value must be divided by the previous vehicle occupancy of new carpoolers of 1.2 to yield

the number of vehicles that are no longer driven to work of 21.9. The next step is to subtract the number of vehicles that will be used as pooling vehicles from the number of vehicles removed. The number of pooling vehicles is determined by multiplying the number of needed poolers 26.3, by the percent who form new carpools 95 and dividing by the vehicle occupancy of carpools 2.85. This equals 8.77 vehicles and subtracting from 21.9 results in 13.1 vehicles being removed. This value is then adjusted for the frequency of carpooling by multiplying by 85 percent to yield 11.1 vehicles. Thus after correcting for vehicle occupancies and additional travel distances only 211 miles or 42.2 percent of the original 500 mile reduction has been attained. To attain the 500 mile reduction the original estimate of 26.3 single occupant vehicles is divided by the percent reduction 42.2, to yield the number of necessary commuters of 62.3. Energy reductions are calculated in a similar manner except that VMT reduction is replaced with the desired reduction in gallons of gasoline and appropriate fuel usage rate.

Algebratic notation. Before developing the algebratic notation of the supply models it is first necessary to define the following variables. In particular:

NC_m = the number of commuters needed to participate in ride-sharing for mode m; m = carpool (c) or vanpool (v).

VMT = desired or target level of reduction in vehicle miles of travel (number of miles).

GR = desired or target level of reduction in fuel (gallons of fuel).

DIST = round trip commute distance (number of miles).

MPG_j = fuel milage (miles per gallon of fuel) for vehicle class j; j = standard (14mpg), compact (16mpg).

PO_m = previous vehicle occupancy of new poolers in mode m (number of passengers per vehicle); 1.2 carpools, 1.79 vanpools.

CO_m = current vehicle occupancy of newly formed pools of mode m (number of passengers per vehicle); 2.85 carpools, 11 vanpools.

PE_m = percent of poolers that form new pools for mode m; 95 for carpools, 100 for vanpools.

FQ_m = percent of poolers that will be pooling any given day for mode m; 85.0 carpools, 95 vanpools.

TC_m = trip circuity of poolers in mode m (miles); 1.0 miles carpools, 1.5 miles vanpools.

PD_m = distance from home to meeting point for those pooling in mode m (miles); zero carpools, 6.46 miles vanpools.

PP_m = percent of poolers in mode m who meet their pool at a designated meeting place; zero carpools, 43.5 vanpools.

The first step in formulating the supply model is to determine the number of vehicles that must be removed from the commuter trip. For a specified VMT reduction and round trip distance, the number of initially removed vehicles for ridesharing mode m, is

$$IVR_m = \frac{VMT}{(DIST - TC_m - (PD_m PP_m))\ PO_m} \qquad (5.1)$$

where,

IVR_m = the number of vehicles initially removed for ridesharing mode m.

and the number of vehicles that new poolers will be using as pooling vehicles for mode m, is

$$PV_m = \frac{VMT\ PE_m}{(DIST - TC_m - (PD_m\ PP_m))\ CO_m} \qquad (5.2)$$

where,

PV_m = the number of vehicles new poolers will occupy for mode m.

Since the initial estimate of removed vehicles included those that will be used as new pooling vehicles, equation 5.2 is subtracted from equation 5.1 to define the number of vehicles removed as

$$VR_m = IVR_m - PV_m \qquad (5.3)$$

where,

VR_m = number of vehicles removed for mode m.

The percent of target or desired vehicle miles actually reduced by ridesharing mode m, out of the desired number and corrected for frequency of pooling for mode m, is

$$PR_m = \frac{VR_m\ FQ_m\ (DIST - TC_m - (PD_m\ PP_m))}{VMT} \qquad (5.4)$$

where,

PR_m = percent of desired vehicle miles actually reduced by mode m.

therefore, the number of commuters needed to participate in ridesharing mode m to achieve a desired VMT reduction, is

$$NC_m = \frac{VMT}{(DIST - TC_m - (PD_m\ PP_m))\ PR_m} \qquad (5.5)$$

Estimating participation levels for energy reductions is determined in a similar manner except that the fuel usage rate is incorporated in the model. In this case the number of initially removed vehicles with fuel usage rate j, and ridesharing mode m, is

$$IVR_m = \frac{GR\ MPG_j}{(DIST - TC_m - (PD_m\ PP_m))\ PO_m} \qquad (5.6)$$

and the number of vehicles that new poolers will be using as pooling vehicles for mode m, is

$$PV_m = \frac{GR\ MPG_j\ PE_m}{(DIST - TC_m - (PD_m\ PP_m))\ CO_m} \qquad (5.7)$$

The number of vehicles removed for mode m, is

$$VR_m = IVR_m - PV_m \qquad (5.8)$$

and the percent of gallons actually reduced with usage rate j and ridesharing mode m, out of the desired number when corrected for frequency of pooling for mode m, is

$$PR_m = \frac{VR_m \quad FQ_m \ (DIST - TC_m - (PD_m \ PP_m))}{GR \ MPG_j} \qquad (5.9)$$

therefore, the number of commuters needed to participate in ridesharing mode m to achieve a desired energy reduction with usage rate j, is

$$NC_m = \frac{GR \ MPG_j}{(DIST - TC_m - (PD_m \ PP_m)) \ PR_m} \qquad (5.10)$$

The supply model for parking demand reductions is formulated in a similar manner as the two previously defined models. The number of commuters needed to participate in ridesharing mode m to achieve a specified reduction in the number of parking spaces, is

$$NC_m = \frac{SR^2}{\frac{SR}{PO_m} - \frac{SR \ PE_m}{CO_m}} \qquad (5.11)$$

where,

SR = number of parking spaces to be reduced.

In the case of vanpooling, a simplified method is to estimate that each vanpool replaces approximately five cars and that van occupancy is 11 riders.

To enable quick use of the supply models a set of figures have been developed to estimate participation numbers for each ridesharing mode. The figures located in Appendix C have been calculated for various round trip commute distances as well as fuel usage rates for two

vehicle sizes. Tabulations have also been made for reductions in parking demand for both modes and are located in Tables C.1 and C.2 of Appendix C. Utilization of the supply model figures is straightforward and requires the following information concerning commuter characteristics.

1. The percent distribution of two way commuter trip lengths. This information may be obtained from O-D studies, journey to work census tabulations, or other planning data or studies that collected information on home to work trip lengths. In cases where this data is not available, it is recommended that the average round trip commute distance for the entire area be used or the national average of 19 miles (U.S. DOT, 1973).
2. In a comprehensive reduction program ridesharing may be one of many strategies being implemented and knowing the portion of the reduction that ridesharing is responsible for greatly affects participation levels. For example, ridesharing may be expected to account for 70 percent of the desired reduction of VMT with transit and other programs encompassing the remainder. Thus the percent of the reduction which ridesharing is expected to account for should be specified, if part of a total program. Also to be specified is the percent participation in each ridesharing mode by new poolers. If both car and vanpooling is being promoted it can be expected that a certain portion of new poolers will carpool while the

others vanpool. Since the two modes require different participation levels to achieve the same reduction, it is important to develop a balance between the modes given the potential of each in the area. In most areas it would be unrealistic to expect vanpooling to capture more than 5 to 10 percent of the total trips unless extensive employer based vanpool programs and financial incentives are undertaken. In these situations vanpooling may capture between 15 and 25 percent of the total trips depending on the intensity of the program.

3. For estimating energy reductions the mix of vehicle sizes in the study area should be determined since each size has a different fuel usage rate. If data are not available it is recommended that the compact car size be used to represent the entire area.

Example application. Use of the figures is most easily explained through the following example. Consider the case of Knoxville, Tennessee where it is desired to reduce daily VMT by 10 percent and current daily VMT is 2.5 million miles. The distribution of two way commute trip lengths in the Knoxville area are as follows: 10 miles, 55 percent; 20 miles, 25 percent; 30 miles, 11 percent; 40 miles, 3.5 percent; and 50 miles, 3.5 percent. Ridesharing is expected to account for 80 percent of the reduction and the split between ridesharing modes is 92 percent carpool, 8 percent vanpool.

The first step is to determine the number of commuters needed to carpool and vanpool for each of the commute distances. These values are obtained from Figures C.1 and C.2 of Appendix C for the 250,000 VMT reduction and are tabulated in columns 1 and 2 of Table 5.4. The next step is to correct these participation levels to reflect the percentage of trips for each commute distance by multiplying the number of commuters by the corresponding percent. Since vanpooling in applicable for commute distances greater than 15 miles oneway, the corresponding percentages for the proportion of trips greater than 30 miles have been normalized to 100 percent (column 4) and multiplied by the corresponding participation levels. These values are tabulated in columns 5 and 6 of Table 5.4. Summing these columns yields 47,272 and 19,147 which is the number of commuters needed to carpool or vanpool to achieve the 10 percent reduction level. If vanpooling was not being considered in the area the number of commuters needed to carpool (47,272) would be the necessary participation level. In our case vanpooling is included and requires that participation levels be adjusted to reflect the percent of participation in each mode. The number of commuters needed to participate is determined by multiplying the participation levels for car and vanpooling by 92 and 8 percent respectively and summing. This results in a total participation of 45,022 commuters. A final adjustment is the 80 percent contribution ridesharing is expected to contribute toward the total reduction goal. Multiplying the total participation level by 80 percent results in 36,018 commuters.

TABLE 5.4 PARTICIPATION LEVELS FOR CAR AND VANPOOLING IN KNOXVILLE, TENNESSEE

Trip Distance (Miles)	Number of Commuters		Percent of Trips for Each Distance (Col 3)	Normalized Vanpool Proportions (Col 4)	Number of Commuters Adjusted for Trips Distribution	
	Carpool (Col 1)	Vanpool (Col 1)			(Col 5)	(Col 6)
10	65,360	98,880	55	0.0	35,948	0
20	30,960	35,860	25	0.0	7,740	0
30	20,280	21,900	13	65	2,636	14,235
40	15,080	15,760	3.5	17.5	528	2,758
50	12,000	12,310	3.5	17.5	420	2,154
Totals			100	100	47,272	19,147

Estimating participation levels for energy reductions are determined in a similar manner except that an additional step is needed to adjust for the mix of vehicle sizes. Figures C.3 thru C.6 of Appendix C are used when analyzing energy reductions.

Summary

Through use of the supply model figures, it is quickly recognized that for even small percentage reductions in VMT and energy usage, participation levels are large and can quickly approach the size of the work force. In the Knoxville application an additional 36,000 commuters would need to rideshare for the 10 percent reduction. Currently the work force is approximately 130,000 individuals and 40 percent (52,000) of these individuals already rideshare. Thus, expecting an additional 36,000 commuters (28 percent of the work force) to rideshare would be questionable unless an extensive change in commuting conditions such as a decrease in the supply of gasoline were to occur.

The supply models have been developed such that they incorporate numerous considerations affecting load factors and travel distances which inturn provides a fairly good estimate of participation levels for decision making pruposes. Proceeding through the process and assessing needed participation levels against the size of the work force, demand estimates of step 5 of the planning guidelines, and the resulting level of program intensity and cost, enables an indepth analysis to be undertaken. Through this assessment, changes can be made to reduction levels if resulting participation values are too

high which readjust the scope of the ridesharing program to acceptable intensity and funding levels. Even with increases in carpool and vanpool occupancies, ridesharing may have a more limited potential than first expected. These implications can quickly be identified through use of the supply models.

CHAPTER VI

RIDESHARING DEMAND METHODOLOGY

An important element in evaluating ridesharing strategies is estimating the increase in new ridesharing arrangements as a result of implementing various ridesharing strategies. This task which is included in the detailed evaluation phase (Step 5) of the planning guidelines is a primary basis for determining which strategies are most effective in increasing ridesharing rates. Planners in estimating demand are especially interested in demand techniques that are easy to use while still being accurate in their forecasts. In the past few years sketch planning techniques which utilize manual methods or very short computer routines have been used extensively by planners in an effort to obtain quick demand forecasts.

At present few quick response techniques are available that assess the demand for ridesharing especially when alternative policies are being evaluated. The proposed sketch planning methodology which is presented in this section was developed in an attempt to fill this void. The analysis attempted to develop a mode split model based on multiple linear regression techniques utilizing easily obtained planning data. After analysis, the methodology did not accurately predict ridesharing mode usage and indicated that the decision to rideshare is based on a combination of complex travel related and attitudinal factors which is difficult to incorporate in models. Since the intent of the analysis was to develop a quick and easy sketch planning technique, no effort was made to expand the methodology to incorporate attitudinal

measures or expand the analysis to include alternative techniques such as logit analysis. As a result of this failure, a review of current demand techniques was undertaken in an attempt to identify acceptable quick response techniques. Through this review three techniques are suggested for estimating potential demand; (1) the Department of Energy's manual mode choice method, (2) administration of local surveys to identified market segments, and (3) examination of previous strategy applications in other communities (FEA, 1976). These techniques are discussed later in this chapter as well as in Chapter VII. Through use of these techniques, quick and inexpensive estimates of potential demand can be made.

The remainder of this chapter is devoted to a general overview of the attempted methodology and model calibration efforts, followed by a review of existing ridesharing analysis techniques and suggest demand estimation techniques.

Proposed Ridesharing Demand Model

General model concept. The proposed methodology attempts to utilize multiple linear regression techniques along with easily obtained planning data to develop a mode split model that distinguishes between individuals who drive alone and those who rideshare. The methodology can be utilized by other communities either through recalibrating the model with local planning data and local mode splits or simply borrowing the model and its relationships under the assumption that travel behavior is similar in the two areas. Through the second approach of using borrowed models, planners will have available a manual sketch planning technique that provides quick estimates of

ridesharing mode splits. The major input requirement to utilizing the manual approach is the information on home-to-work trip distances for the various market segments under study and associated travel data for the two modes.

In developing the model special attention is directed at utilizing variables that are easily available to planners through O-D surveys, census data or other travel surveys, while avoiding those variables that are attitudinal in nature. Even though studies have reported that attitudinal measures such as convenience or knowing fellow riders are good predictors of ridesharing mode split their exclusion is based on a number of reasons (Stopher, 1976).

1. Attitudinal measures are multifaced and ambiguous and in most instances perceived differently from one area to another. Congestion or convenience attitudes may be entirely different from one area to another or from one person to another and could give misleading results if these measures contributed significantly in the model.
2. Attitudes do not remain constant over an extended period of time and are considered to be sensitive to new information. With the continued increase in gasoline prices and its reduced availability, convenience related attitudes toward ridesharing may change considerably.
3. Attitudinal measures are not well suited for evaluating alternative transportation policies since it is difficult to alter variable values to reflect changes in convenience or comfort. If attitudinal measures are the primary decision variables for choosing ridesharing, it would be difficult to

forecast meaningful results since policy sensitive variables such as travel cost and time would contribute little to model predictions.

4. Attitudinal measures pertaining to ridesharing are not readily available in most communities and consequently would require measurement or borrowing of average values from other areas which most likely would not be representative.

The proposed mode split analysis is based on developing a utility function through linear regression techniques rather than simple diversion ratios or logit analysis. A major drawback to many policy sensitive models is the use of logit analysis and the difficulty in understanding its theoretical formulation. Regression analysis on the other hand is more widely understood by planners and requires considerably less time to calibrate. In most organizations, regression analysis could be performed by inhouse staff in a relatively short time period given the easily obtained data requirements of the model.

Other modeling techniques such as discriminate or probit analysis are also suitable for mode choice analysis but are not considered since they also require extensive knowledge of the technique which is commonly not available in a local planning organization.

Model development. The mode split analysis is centered around the development of a linear regression function which estimates an individual's utility for ridesharing and driving alone. These utility estimates are then used to measure the relative attractiveness of the two modes by calculating a disutility which is the difference between the two modal utilities for each individual. The final model structure

is then developed by determining the proportion of individuals who were observed to rideshare and plotting these proportions against the calculated disutilities. The resulting graph like that shown in Figure 6.1 defines a diversion line which indicates the proportion of individuals ridesharing for a given disutility. It should be pointed out that the diversion line is defined by observed proportions rather than estimated probabilities as is the case in logit analysis.

To utilize the model in sketch planning analysis, planners would estimate values for variables included in the model for those market segments being analysed, compute the disutility for each segment and determine the proportion of commuters ridesharing from the diversion line figure. To more accurately represent travel patterns, the analysis can be refined by determining the distribution of trip lengths for each market segment and rideshare proportions for each distance category.

The utility function is determined through multiple regression analysis with the utility of each individual person expressed mathematically as:

$$U_{ik} = a_o + a_1 X_{1k} + a_2 X_{2k} + \ldots + a_n X_{nk} \qquad (6.1)$$

where,

U_{ik} = the utility of mode k to individual i.

a_i's = coefficients which estimate the relative influence of socioeconomic characteristic or model attributes in determining the attractiveness of each mode i.

x_k's = the vector of socioeconomic characteristics of individual i and/or attributes (distance, time) of moke k.

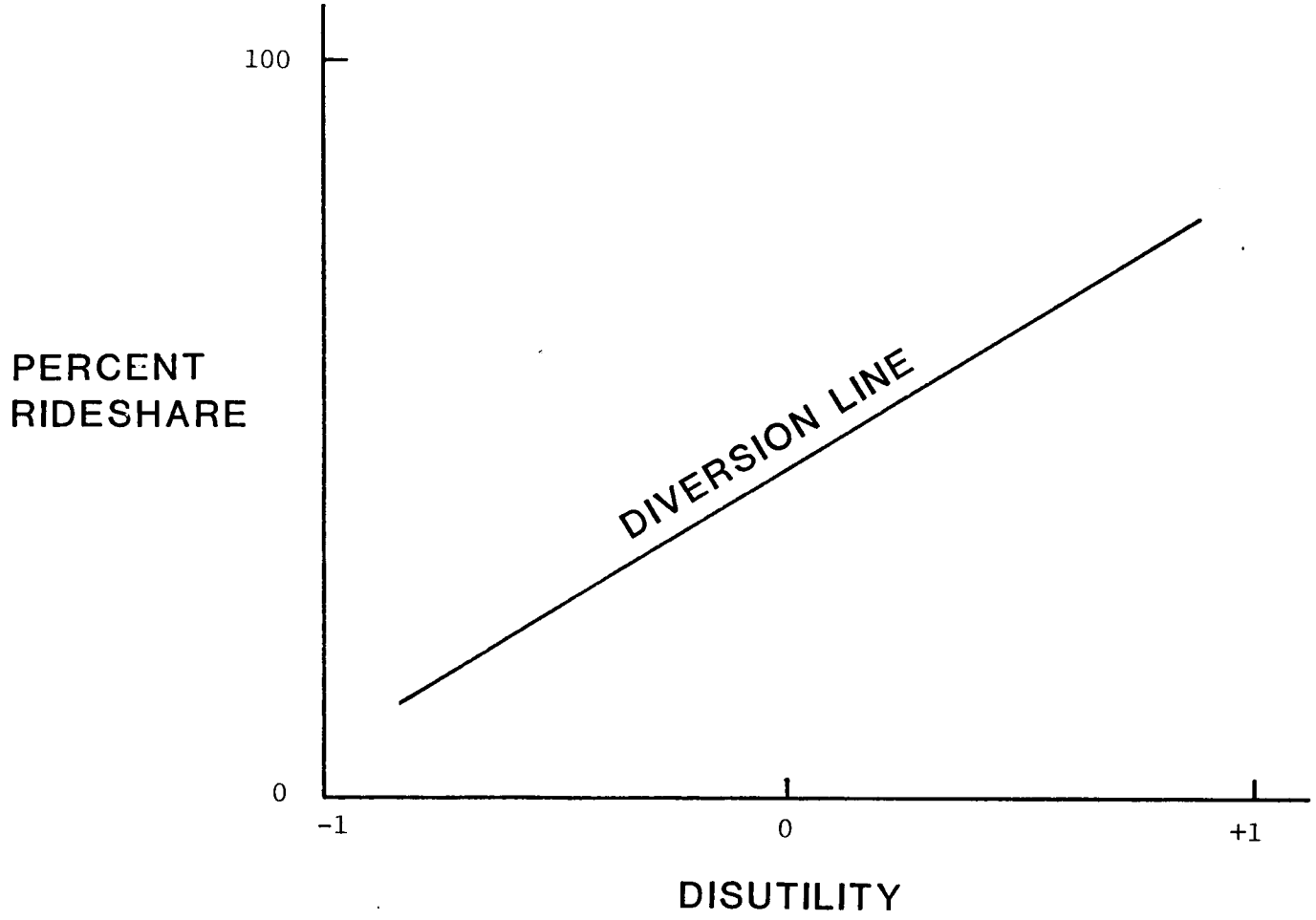


FIGURE 6.1 THEORETICAL DIVERSION LINE

A disutility is then computed for each individual by taking the difference between the two computed modal utilities, and is expressed as:

$$DU_i = U_{irs} - U_{ida} \qquad (6.2)$$

where,

DU_i = disutility of individual i.

U_{irs} = utility of ridesharing mode to individual i.

U_{ida} = utility of drive alone mode to individual i.

In developing the utility function through multiple regression, special problems arise in the theoretical formulation since the dependent (predictor) variable is dichotomous (0,1). The first area of concern involves nonnormal error terms and their ability to take on only two values when the dependent variable is dichotomous. Using a simple linear regression model as an illustration, the two values are:

$$\text{When } Y_i = 1 : E_i = 1 - B_o - B_1 X_i$$

$$\text{When } Y_i = 0 ; E_i = B_o - B_1 X_i$$

Consequently the normal error regression model which assumes that the E_i is normally distributed is no longer appropriate. Even though the error terms are not normal, least squares still provides unbiased estimators which, under quite general conditions, are asymptotically normal. Hence, when the sample size is large, inferences concerning the regression coefficients and mean responses can be made in a similar fashion as when the error terms are assumed to be normally distributed (Neter, 1974).

A second problem that arises as a result of the nonnormal error terms is the lack of goodness-of-fit measures since they rely on the normality of the error term. This problem is overcome by utilizing a

split sample technique to calibrate the model. In this technique the original data set is split into two samples, one sample is used to calibrate the model while the other serves as a validation sample for the calibrated model. If similar results are obtained in the validation sample, the model is assumed to be representative of the data.

A final problem involves the response function and the constraint that mean responses should fall between zero and one, since the response function represents probabilities when the dependent variable is an indicator variable. Most response functions do not possess this constraint and values may fall outside the constraint limits even when values of the independent variables are within the scope of the model. Constraining the response function can be handled through means of a logistic or logit transformation of the response value. In the case of the model being developed, use of the response function is not contingent on obtaining a probability but rather just defining a utility for each mode. Since the model is attempting to determine the mode split based on the difference between utilities for each mode rather than determining the probability of selecting a given mode, it is not essential that the utilities be constrained.

In logit models, mode split is determined by defining the probability of selecting each mode and then summing the probabilities for all individuals by mode to determine the number of individuals utilizing each mode and the corresponding proportions. In this case it is necessary that probabilities be constrained since values greater than one or less than zero would be meaningless.

Even though these three problems create theoretical restraints, solutions have been found which avoid them. Consequently, with the use

of a large sample size, split sample techniques and the nonuse of mode split probabilities, linear regression analysis becomes an acceptable analysis procedure.

Model calibration. The basis for all modeling and analysis was three travel surveys conducted in conjunction with the Knoxville Commuter Pool evaluation program. A copy of the three survey instruments along with survey procedures are included in Appendix B. Surveys 1 and 2 of Appendix B were telephone surveys of individuals participating in the Knoxville Commuter Pool matching program while Survey 3 was a self-administered mailback survey of downtown employees working at four different employers.

In the case of the telephone surveys, all individuals had shown some interest in ridesharing since their names were obtained from the Knoxville Commuter Pool matching lists and consequently do not represent a purely random sample of workers from the community. The same can be said of the survey of four downtown employers. Even with this bias towards downtown employees and the fact that individuals had filled out a computer match form, the data is felt to be representative of the entire community. The data comprises a good cross section of individuals from the community with varied home and work combinations which are typical of travel patterns and mode splits in the Knoxville area. In addition, the sample data is a combination of four separate surveys which tends to offset the biases contained in any one survey.

Data that were collected includes basic socioeconomic characteristics and information on individual work trip mode, time, distance, and cost. Variables included in the analysis were:

NOVEH = number of vehicles per household;

H DENSY = residential density, number of persons per square mile;

W DENSY = work site density, number of employees in the surrounding work area (one mile square grid used in carpool matching);

EMPPOP = employer population, total number of employees employed by employer;

HWDIST = home-to-work travel distance for mode i (miles);

HWTIME = home-to-work travel time for mode i (minutes);

Age = individuals age grouped into four categories;

Income = individuals income grouped into four categories;

Sex = individuals sex (0 or 1);

P COST = actual parking cost incurred by each individual for current mode used;

O COST = actual round trip out-of-pocket operating cost incurred by each individual for current mode used, (5 cents per mile);

T COST = actual round trip total cost incurred by each individual for current mode used, (parking cost plus out-of-pocket operational cost);

DAPC = parking cost for the drive alone mode;

DAOC = operating cost for the drive alone mode;

DATC = round trip total cost for the drive alone mode;

RSPC = parking cost for the ridesharing mode;

RSOC = round trip operating cost for the ridesharing mode;

RSTC = round trip total cost for the ridesharing mode;

DP COST = difference in parking cost between the two modes;

DO COST = difference in round trip operating cost between the two modes;

DT COST = difference in round trip total cost between the two modes;

In coding values for these variables, assumptions were made in certain cases since direct values were not reported in the survey instruments. A brief discussion is presented on the source of data for each variable since the assumptions associated with a few of the variables place some limitations on the data. Variable values for NOVEH, Age, Income, and Sex were obtained from each survey instrument. Values for H DENSY, W DENSY and EMPPOP were obtained from residential and employment densities by traffic zone for Knox County. Parking cost (P COST) was asked in Survey 3 and the reported cost was coded. In cases where parking was not reported an average value of $1.06 per day for downtown Knoxville was coded if the respondent worked downtown and the employer did not provide free parking. This assumption was applied to all three survey forms and presents a drawback since some commuters who work in the CBD do not pay for parking but rather park in nearby neighborhoods or are provided free parking by employers. In the case of the ridesharing mode, it was assumed that the carpool's final destination was the CBD, that all paid for parking, and the cost was evenly divided between each rider in the pool. The situation could exist where riders were just dropped off at work with the driver working at a nonCBD location and consequently not paying to park. In calculating operating cost (O COST) it was assumed that only out-of-pocket costs would be

included since few commuters consider depreciation, insurance and maintenance costs. A value of five cents per mile was assumed which represented fuel costs in Knoxville at the time of the survey with a fuel usage rate of 12 miles per gallon. The operating cost was then computed by multiplying by the round trip commute distance. It should be pointed out that actual out-of-pocket costs could vary considerably, depending on the fuel usage rate of the vehicle driven to work and total operating costs could also vary if the individual considered the true cost of operating the vehicle. Travel time and distance values were obtained from current minimum time and distance paths for the Knoxville street network.

Parking and operating costs for the drive alone mode (DAPC, DAOC) were determined by using the $1.06 default parking cost if the work site was in the CBD and free parking was not provided and multiplying the round trip commute distance by five cents per mile. Parking and operating costs for the ridesharing mode (RSPC, RSOC) were determined in the same manner as the drive alone mode except that these final costs were then divided by the number of reported carpool riders or the average occupancy of carpools from the three surveys, 2.33 persons. In the cases where actual costs were reported, these values were coded for the appropriate costs for each mode. The differences in costs between the two modes was determined by substracting the rideshare cost from the drive alone cost.

From this discussion, it is seen that the assumptions used in determining travel costs, both parking and operational fail to provide a precise measurement for these values. In determining these costs, average values were frequently used which may reduce the ability to

distinguish between the two groups. If the survey instruments had initially been designed with the intent to collect data for modeling mode choice, specific questions addressing costs would have been included to avoid these drawbacks. Since this was not the case, these assumptions are considered to be the best alternatives given the extent of the data.

The three surveys yielded a total combined sample of 1012 observations but after deleting for missing responses the sample was reduced to 796. The sample was then randomly split into two equal samples of 398 for model formulation.

As stated previously, the methodology for model development utilizes multiple linear regression where the dependent variable is the observed mode, (ridesharing or drive alone) and independent variables being modal attributes or socioeconomic characteristics. Initially regression analysis was used to investigate several model forms which were comprised of various combinations of independent variables. These models revealed that socioeconomic characteristics and those variables which measure the difference in travel costs between modes were poor indicators in discriminating between modes. Appendix D contains a summary listing of the various model combinations investigated.

Separate models were also constructed for CBD and nonCBD commuters to determine if model variables differ by market segments. These results are included in Appendix D and indicated that model variables were similar between segments, but that the CBD model had better predictive powers than the nonCBD model as indicated by R-square values of 0.68 and 0.63 for the two models respectively. As a result of the similarity between the two segments, data sets were combined and an

additional CBD dummy variable was incorporated to identify the work location. Results of regression analysis utilizing this combined data set are listed in Table 6.1 and are relatively similar to those obtained with separate data sets except for the inclusion of the CBD dummy variable. From examining Table 6.1 it is seen that after the inclusion of the CBD variable, the remaining variables explain little of the remaining total variance. As a result, the final model includes those variables in the first seven steps except for the parking cost and number of vehicles per household variables. The parking cost variable is excluded since it explains little variance when operating and total cost variables are also included in the equation. Removing parking cost from the equation casues the number of vehicles per household variable to become less significant and consequently it is also dropped from the equation. Table 6.2 lists the variables included in the final equation along with their coefficients, standard errors, and "F" statistics. The variables included in the equation appear justified from a casual relationship in distinguishing mode split, except for the exclusion of the travel time variable. Its exclusion most likely is a result of its high correlation (.89) with travel distance. Travel time, while being a policy sensitive factor, was not forced into the equation since it would contribute little to final utility values and the fact that few alternative ridesharing policies that involve travel time savings are applicable to small and medium sized cities.

The performance of the model in regards to classifying individuals as either driving alone or ridesharing is presented in Table 6.3 for both the calibration and validation data sets. As seen, the model was consistent across both data sets and correctly classified 94.2 and 93.2

TABLE 6.1 REGRESSION OF COMBINED CBD AND NON-CBD DATA SETS[a]

Step Number	Variable Entered	R - Square
1	T COST	.2282
2	HWDIST	.4348
3	P COST	.5995
4	CBD Dummy Variable	.6283
5	O COST	.6355
6	NOVEH	.6407
7	WDENSY	.6460
8	SEX	.6520
9	EMPPOP	.6532
10	Age 2	.6537
11	Age 3	.6571
12	Age 4	.6574
13	HWTIME	.6576

[a]Number of observations = 398

TABLE 6.2 FINAL REGRESSION EQUATION

Variable	Coefficient	Standard Error	Partial "F" Statistic
Constant	0.28690		
WDENSY	0.82028E-05	0.27684E-05	8.78
HWDIST	0.70978E-01	0.41642E-02	290.50
O COST	-0.48891E-02	0.78479E-03	38.81
T COST	-0.39686E-02	0.46100E-03	74.11
CBD Dummy Variable	0.22819	0.42744E-01	28.50

TABLE 6.3 MODEL CLASSIFICATION RESULTS
(Percent Right)

Group	Calibration Sample (N=398)	Validation Sample (N=398)
Drive Alone (number correct)	99.2 (256/258)	98.1 (256/261)
Rideshare (number correct)	85.0 (119/140)	83.4 (115/137)
Total	94.2 (375/398)	93.2 (371/398)

percent of the individuals for the calibration and validation data sets respectively. Since similar classification rates were obtained from the validation data set, the model is considered to significantly represent the data. The lower correct classification rates for the ridesharing group (85.0 and 83.4 percent for the calibration and validation data sets respectively) can be attributed to those individuals with a short commuting distance who rideshare. In general it is less likely for an individual with a short commuting distance to rideshare since the monetary savings are less. It appears that in these cases other factors such as the proximity of pool members or their compatibility with each other are added incentives for ridesharing.

The final step in formulating the model is to construct a ridesharing diversion line by computing a disutility for each individual. Disutilities were determined as defined in equation 6.2 by computing modal utilities for each individual through use of the final regression equation. The same equation was used to compute each modal utility since it was developed over commuting values for both modes. Individual disutilities were then grouped in 0.05 intervals and plotted against observed ridesharing proportions for each interval as shown in Figure 6.2. As seen from the graph, a well defined line does not exist from the data. At most the results follow the general mode split of the data rather than indicating higher ridesharing proportions for larger disutility values. In theory one would expect ridesharing proportions to be low with small disutilities values and increase as disutilities grow larger. In the case of logit analysis, the calibrated "S" shaped curve always follows this principle since it is defined through theoretical values rather than observed proportions.

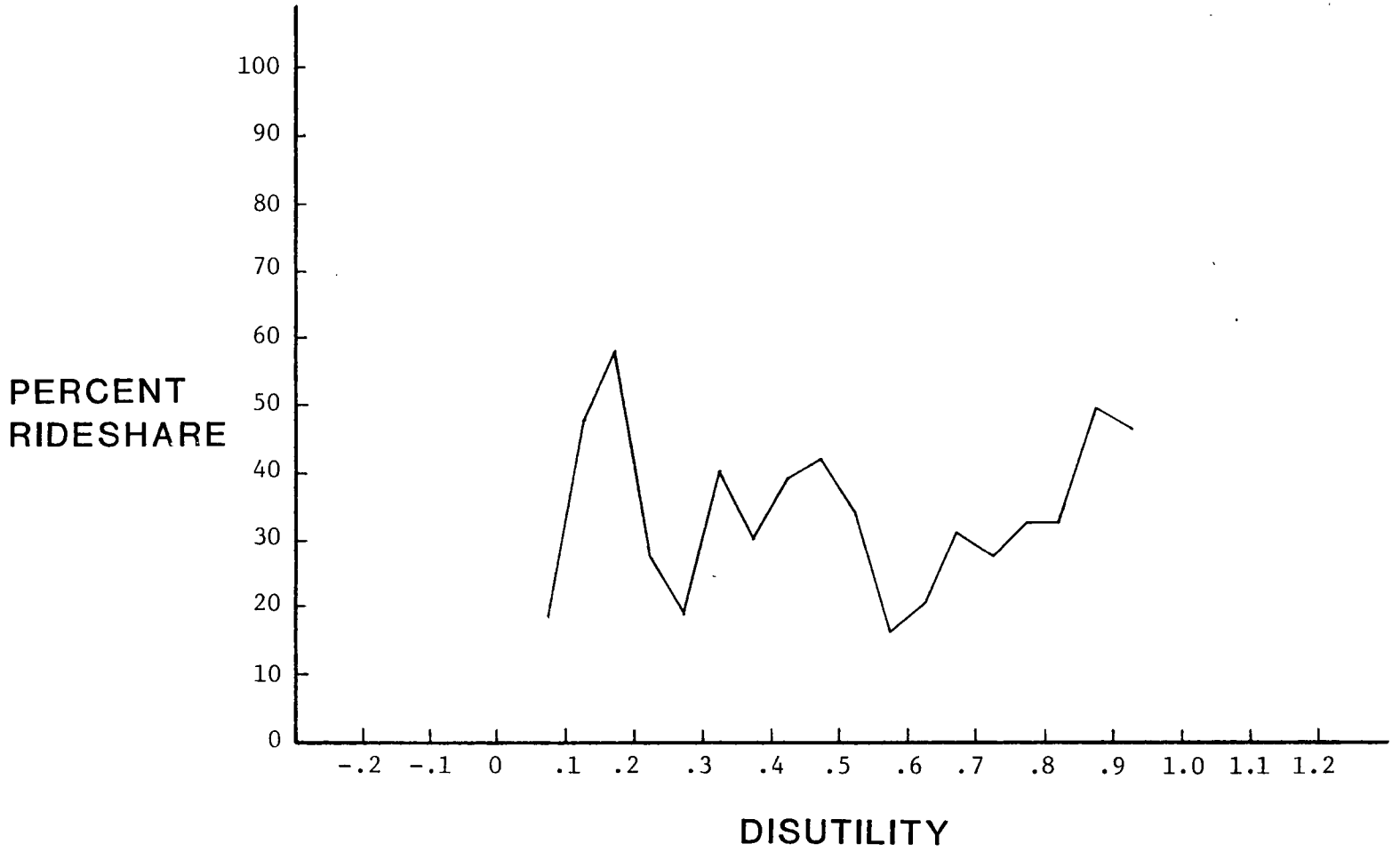


FIGURE 6.2 OBSERVED PROPORTION OF INDIVIDUALS RIDESHARING BY DISUTILITY

Plotting observed proportions against disutility values in logit analysis may result in a similar erratic pattern.

In developing the regression equation it was felt that the weak results might be a result of including commuters who carpooled with family members in the ridesharing group since different motivating factors may cause these individuals to rideshare. Removing family carpool commuters from the sample and recalibrating the regression equations resulted in similar results. The same variables were again the best estimators in distinguishing between modes which indicates that based on the variables considered in the analysis, family carpool commuters are similar to others who rideshare. Final regression results with the exclusion of family carpools are contained in Appendix D.

The results obtained indicate that accurate ridesharing proportions cannot be estimated through the regression equation. It suggests that other factors not included in the equation are also important in the decision to rideshare. As previously discussed in the attitudinal section Chapter 4, factors such as convenience; knowing an individual who lives or works with you; compatability with pool members; or dislike of driving in rush hour traffic are additional reasons for ridesharing that are difficult to represent in models. These factors also present problems in policy analysis since few strategies address these issues. Most strategies are directed at cost and time savings rather than convenience or other social factors. As a result, policy analysis could be expected to be less sensitive and produce small increases in ridesharing proportions since few policies would directly affect these attitudinal decision variables.

Even though factors such as travel time, distance, and cost were unable to distinguish between modes, they are still important reasons for choosing to rideshare for certain market segments. As indicated in previous sections, these factors in the form of preferential lanes, priority or reduced costs of parking, or reduced commuter tolls, influence many commuters to rideshare and should not be overlooked when defining strategies for various market segments. The modeling effort appears to indicate that given the current environment, additional factors are necessary to model ridesharing mode split. The incorporation of these additional attitudinal factors will not be made in this analysis since the initial intent was to develop a simple easy to use mode split model. Currently, there exists several techniques which attempt to estimate rideshare mode split, some incorporate attitudinal measures and utilize sophisticated techniques such as logit analysis while others are less entailed and sketch planning oriented. Since this analysis failed to accurately model mode split, a review of these techniques will be made in the following section to assess their usefullness in providing quick inexpensive mode split estimates.

Current Ridesharing Demand Methods

As a result of the inability to adequately model ridesharing mode splits in the preceding section, a review of current available methods is undertaken in an attempt to identify a reliable technique which is quick and simple to use. Current methods can be classified into two groups, those that predict mode split on a disaggregate basis and those that estimate potential rideshare markets from travel characteristics. In examining current demand methods a brief discussion of disaggregate

mode split models is first presented followed by a review of four disaggregate mode split models developed for Pittsburgh, PA, Washington, DC, Twin Cities Area (Minneapolis/St. Paul, MN), and the Department of Energy, and three market identification techniques; Service Area Identification Methodology, Baltimore Vanpool Model, and Highway Network Models.

Disaggregate mode split models. One method of forecasting the effects on travel demand from alternative ridesharing actions that has received considerable attention in the past few years is disaggregate travel demand models. Disaggregate mode split models have been developed which are capable of estimating the travel behavior impacts of a full spectrum of short range TSM strategies, including many ridesharing options.

Disaggregate demand models are all based on the concept that the probability that an individual will choose a particular alternative is a function of the characteristics of the individual and of the overall desirability of the chosen alternative. There are several forms of the model with the logit form being the most commonly used formulation of the probability function. The function is expressed in the form:

$$P_{it} = \frac{\exp\ (U_{it})}{\sum_{j=1}^{n} \exp\ (U_{jt})}$$

where,

P_{it} = the probability of individual t choosing alternative i.

U_{it} = the utility of alternative i to individual t.

U_{jt} = the utility of alternatives j to individual t.

The model is based on the principle that individuals will choose the alternative mode which maximizes their utility. The utility function is usually expressed in a linear form comprised of attributes of the alternative modes such as travel cost, time, and distance, and socio-economic characteristics of the individual such as income, auto ownership, etc. The utility functions are calculated through "maximum likelihood estimation" which yields a set of constants and weighing coefficients for the utility expressionin the following form:

$$U_{it} = a_o + a_1x_1 + \ldots + a_nx_n \qquad (6.4)$$

where,

a_o = the modal constant or bias coefficient which represents the influence of all those characteristics not explicitly included as variables in the model.

a_i, a_n = coefficients which estimate the relative influence of each modal attribute or socioeconomic characteristics in determining the attractiveness of each mode i.

x_i, x_n = the vector of attributes of alternative mode i or socioeconomic characteristics of individual t.

The model is then used to forecast changes in mode choice participation by adjusting the values of modal variables to reflect changes in policies toward different modes. For example, if a parking surcharge tax is being considered the commuting cost variable would be adjusted to account for this additional travel cost.

There are several advantages as well as disadvantages in using disaggregate models versus traditional aggregate mode split analysis. Key properties which make disaggregate models advantageous include:

1. Disaggregate models are calibrated on osbervations from individual household units rather than combining households to establish zonal or district levels. This in turn enables the model to be used at any geographic level, area wide, subarea, or corridor and requires considerably less data to calibrate than aggregate models.
2. By calibrating on an individual basis rather than an aggregate one, more efficient use of the data is made since a large portion of variation is attributed to grouping of data to obtain zonal averages.
3. Disaggregate models can be more easily transfered from one geographic area to another since they are less susceptible to the location biases associated with zonal aggregate data.
4. The linear utility expression in disaggregate models consists mainly of variables which describe the level of service provided by each alternative mode. By modifying the values of these variables a variety of ridesharing policies can be represented.
5. Disaggregate models are capable of comparing any number of alternative choices (drive alone, carpool, vanpool and transit) simply by specifying the attributes of each mode offered to the individual.

Even with these advantages, behavioral disaggregate demand models have not received widespread acceptance by many transportation planners

especially those in small and medium sized communities. Most applications have occurred in large metropolitan areas by consulting firms or planning organizations with large staffs and expertise in disaggregate modeling. Smaller planning staffs have shied away from behavioral disaggregate models because of the experience needed to develop and calibrate the models. The initial calibration procedures require a considerable amount of time and resources which usually cannot be accommodated by communities with small staffs. Even if a model is borrowed from another community it must be recalibrated to the new area which necessitates a thorough understanding of the principles of disaggregate models.

Recently three separate disaggregate mode choice models have been developed for Pittsburgh, PA, Washington, DC, and the Twin Cities Area (Minneapolis/St. Paul, MN) which estimate expected rideshare mode split. In all cases the models are of the multinomial logit form.

Pittsburgh model. The Pittsburgh model was developed to predict mode share between three alternatives; public transit, drive alone auto, and carpool (Lyles, 1979). The model was calibrated on 404 observations taken randomly from a useful sample of 808. Initially some 107 candidate variables were considered in developing the model with the majority being eliminated by "first cut" multiple regression runs for each mode. The final model was calibrated through maximum likelihood estimation which yielded the variables and coefficients listed in Table 6.4. The variables included in the model are defined as follows:

TABLE 6.4 VARIABLES USED IN PITTSBURGH MODE SPLIT MODEL

Variable	Coefficient (Standard Error)
In Vehicle Time	-0.0303 (0.0128)
Total Cost	0.0154 (0.0021)
Transit Availability	1.0554 (0.30896)
Convenience	0.5644 (0.30896)
Distance, Drive Alone (DA)	0.00061 (0.102)
Distance, Carpool (CP)	0.00108 (0.00028)
CBD constant, DA	-4.2249 (0.6035)
CBD constant, CP	-2.4759 (0.3997)
Expense	-0.8862 (0.1155)

In-Vehicle Time	=	Time actually in the vehicle when traveling to work and was determined from questionnaire response for the mode chosen and calculated for other modes.
Total Cost	=	The values were determined analogously to in-vehicle time and includes all out-of-pocket costs for the trip.
Transit Availability	=	Identifies whether transit is available for the trip by taking a value of 1 if transit is available and 0 if it is not.
Convenience	=	This variable is qualitative in nature and is the respondent's perceived convenience of the chosen mode relative to the other modes.
Distance	=	Is expressed as two mode specific variables and measures the effect of distance on choosing the drive alone or carpool alternatives respectively, relative to public transit.
CBD Constant	=	Measures the impact of the CBD as a work place on mode selection. It takes a value of 1 when the traveler has the CBD as a destination and 0 otherwise.
Expense	=	This is a qualitative expression of the perceived difference in cost between mode alternatives.

Validating the model on the total sample of 808 observations resulted in overall mode split being correctly predicted for 74 percent of the individuals. Examining the predicted results by each mode, the model predicted transit quite accurately at 89 percent, but was inaccurate in the split between drive alone and carpool choices with 52 and 76 percent correct classification, respectively. Even after incorporating additional variables in the model, no appreciable increase in the percent correctly classified was obtained.

Washington, DC, model. The Washington, DC model was developed by Cambridge Systematics, Inc., for the Federal Energy Administration (FEA, 1976d). The mode split model is one element of three behavioral travel demand models sequentially linked together and used to investigate changes in ridesharing participation resulting from policy changes. The remaining two models predict auto ownership and nonwork travel with the work trip mode split model falling between. The model was calibrated on 800 observations from a 1968 updated home interview travel survey conducted in Washington, DC. The model was developed to predict mode share between three alternatives; transit, carpooling and driving alone. Table 6.5 lists the variables and coefficients used in the Washington, DC model along with standard errors and "t" statistics that indicate the degree of statistical significance of each variable. Since the model incorporated modal constants for the drive alone and shared ride mode, predicted base modal shares were equal to observed mode splits in validation runs.

Twin cities model. The Twin Cities mode split model was developed by R. H. Pratt Associates, Inc., in 1975 as part of an overall updating

TABLE 6.5 WASHINGTON WORK MODE CHOICE MODEL

	X_i, S_t Variable	Definition	Mode: Car	Mode: Shared	Mode: Transit	Standard Error	"t" Statistic
1.	D	Drive alone constant	-3.24			.473	-6.86
2.	Ds	Shared ride constant		-2.24		.401	-5.60
3.	OPTC/INC	Out-of-pocket travel cost divided by income	-28.8	-28.8	-28.8	12.7	-2.26
4.	IVTT	In-vehicle travel time	-.0154	-.0154	-.0154	.0057	-2.67
5.	OVTT/DIST	Out-of-vehicle travel time divided by distance	-.160	-.160	-.160	.039	-4.08
6.	$AALD_c$	Auto availability (drive alone only)	3.99			.395	10.08
7.	$AALD_s$	Auto availability (shared ride only)		1.62		.305	5.31
8.	BW_c	Primary Worker (drive alone only)	.890			.186	4.79
9.	GW_s	Government worker (shared ride only)		.287		.161	1.78
10.	$DCITY_c$	CBD work place (drive alone only)	-.854			.311	-2.75
11.	$DCITY_s$	CBD work place (shared ride only)		-.404		.298	-1.36
12.	$DINC_{c,s}$	Disposable income (drive alone & shared ride only)	.000071	.000071		.00002	3.46
13.	$NWORK_s$	# of workers (shared ride only)		.0983		.905	1.03
14.	$DTECA_s$	Employment density (shared ride only)		.00065		.00049	1.34

of the existing travel demand forecasting process. Two different mode split models were developed, one a three mode model distinguishing between drive alone, group ride, and transit and the other a five mode model in which the alternative modes consisted of drive alone, autos with two occupants, three occupants, four or more occupants, and transit. The second model was developed in an attempt to eliminate the use of an auto occupancy model for the three mode model. The models, both mutinomial logit formulations were calibrated on 31,686 observations taken from a 1970 home interview survey conducted in the Twin Cities. Initial calibration runs were performed with 48 variables which described socioeconomic characteristics of the tripmaker and the attributes of each alternative mode. The variables and associated coefficients for the three and five mode models are listed in Tables 6.6 and 6.7 respectively. The variables are defined as follows:

WALK = walk time to and from the transit system;

WAITI = the waiting time to board the first transit vehicle;

WAIT2 = the waiting time to board the second and subsequent transit vehicles;

TRN RUN = the time spent riding in the transit vehicle;

AUTO ACC = the time spent riding in an automobile to get to the transit system;

FARE = the transit fare;

AUTO CONN = dummy variable signifying if an automobile was required to access the transit system;

TRFRS = the number of transfers required;

TABLE 6.6 VARIABLES AND COEFFICIENTS FOR THE TWIN CITIES THREE MODE MODEL

	Mode		
Variable	Transit	Drive Alone	Group Ride
WALK + WAIT1	-0.044		
WAIT1	-0.032		
FARE	-0.020		
TRN RUN + AUTO ACC	-0.032		
AUTO CONN	-0.0957		
HWY EXC		-0.257	-0.342
HWY RUNG		-0.32	-0.32
HWY COSTG		-0.020	-0.020
INC		+0.567	+0.336
HWY DIST			-0.009

TABLE 6.7 VARIABLES AND COEFFICIENTS FOR THE TWIN CITIES FIVE MODE MODEL

	Mode				
Variable	Transit	One Occupant	Two Occupants	Three Occupants	Four or More Occupants
WALK + WAIT2	-0.044				
WAIT1	-0.030				
FARE	-0.014				
TRN RUN +					
AUTO ACC	-0.031				
AUTO CONN	-0.0866				
TRN ACC	+0.020				
HWY EXC		-0.206	-0.349	-0.605	-0.605
HWY RUN		-0.031	-0.031	-0.031	-0.031
HWY COST		-0.014	-0.014	-0.014	-0.014
INC		+0.606	+0.0239	-0.078	-0.282

TRN ACC = the transit accessibility, the percent of attractions within 30 minutes of the origin or destination zone via transit;

TRN EXC = transit excess time, the fum of walk and wait times;

HWY RUN = the time spent riding in the automobile;

HWY EXC = the time spent parking and unparking the automobile;

HWY DIST = the highway distance;

DEN = the zone-to-zone interchange trip density;

INC = the four income quantities;

Model validation was performed using two different data sets. The first data set was the original home interview survey while the second was from a survey collected as part of the I-35 Urban Corridor Demonstration Project. It was felt that the second data set would prove a good test of the model's forecasting abilities since it was collected several years after the home interview.

Applying the models to the home interview survey, both the three mode model and the multimode model performed quite well overall as shown in Table 6.8. The models tended to underestimate transit trips and to overestimate auto passenger trips to the CBD's. Validation with the second data set also produced overall acceptable results with the models estimating transit trips extremely well.

Overall the three disaggregate models predicted base year modal shares extremely well except for the Pittsburgh model. Data requirements are somewhat extensive in all cases with the collection of data

TABLE 6.8 COMPARISON OF TWIN CITIES MODELS WITH O/D SURVEY RESULTS

Trips Attracted to	O/D Survey Results	Multi-Mode Model Estimated Value	Multi-Mode Model Percent Error	Three Mode Model Estimated Value	Three Mode Model Percent Error
MINNEAPOLIS CBD					
Auto Driver Trips	117,013	117,938	+0.79	116,928	-0.07
Auto Passenger Trips	51,660	52,560	+1.74	53,031	+2.65
Transit Passenger Trips	55,685	53,854	-3.29	54,396	-2.31
Transit Mode Share (%)	24.82	24.00	-3.29	24.25	-2.31
Auto Occupancy	1.44	1.45	+0.69	1.45	+0.69
ST.PAUL CBD					
Auto Driver Trips	76,377	75,245	-1.48	74,097	-3.01
Auto Passenger Trips	31,960	33,604	+5.14	34,097	+6.69
Transit Passenger Trips	24,947	24,430	-2.07	25,105	+0.63
Transit Mode Share (%)	18.82	18.33	-2.07	18.84	+0.63
Auto Occupancy	1.42	1.45	+1.87	1.46	+2.82
TOTAL TWIN CITIES AREA					
Auto Driver Trips	2,469,923	2,473,541	+0.15	2,445,422	-0.99
Auto Passenger Trips	1,262,923	1,257,454	-0.40	1,286,185	+1.87
Transit Passenger Trips	150,182	150,529	+0.23	149,937	-0.16
Transit Mode Share (%)	3.87	3.88	+0.23	3.86	-0.16
Auto Occupancy	1.51	1.51	-	1.53	+1.32

being time consuming and costly. Only in the case of the Pittsburgh model was an attitudinal measure used, that being convenience. Even with their accurate base year predictions, the major drawback in calibrating and utilizing these techniques is the necessity of an indepth understanding of logit analysis which is not available in most planning organizations.

In addition to these three computer models, a manual quick response demand method was developed for the Department of Energy from coefficients of the Washington, DC model. A discussion of this technique follows.

DOE manual method. The Department of Energy's (DOE) manual method of estimating carpool, vanpool, and transit mode choice was developed by Cambridge Systematics, Inc., in 1976 in conjunction with the Washington, DC mode split model which was previously discussed in this chapter (FEA, 1976d). This manual method presents a set of guidelines which provide a simple set of procedures for analyzing transportation related measures being considered to increase carpooling, vanpooling, and transit. Specific outputs of the method are: estimates of revised market or modal shares for driving alone, shared ride, and transit; changes in carpool size and auto occupancy; and reductions in daily vehicle miles of travel for candidate program measures taken either individually or in combination. Determining changes in travel patterns is based upon utilizing the coefficients derived from the Washington, DC mode split model. These coefficients have been applied to three other large urban areas and have produced remarkably similar results.

Predicting revised modal shares is based on data describing both existing travel patterns and the proposed changes in transportation level of service. By employing an incremental approach in which travel demand coefficients are used to pivot about an existing situation, data requirements are greatly reduced and only estimates of existing modal shares, travel distances, and proposed changes in the transportation level of service (travel time, and costs) for any given program measure are necessary.

The methodology can be applied to individual employers or area wide analysis as well as subdividing the relevant analysis population into a number of descrete classes of subgroups in order to achieve a higher degree of homogeneity within each group analyzed. For each classification, estimates of revised travel patterns are made using estimated base modal shares and level of service changes for that particular group. The total aggregate or area wide forecast, then, is the weighted sum of the forecasts for each population group.

Utilization of the method varies between a few hours to one or two days depending upon the availability of data and the degree of population subdivision desired. In some instances additional application time may be necessary to determine input data on base modal shares and travel distances for various subpopulations which are not readily available.

In applying this methodology, an important consideration is the transferability of modal coefficients to other areas. As mentioned earlier, calibration of the model to three other urban areas (Los Angeles, San Francisco, and Birmingham) resulted in similar coefficient values, but its application in other areas should still be approached

with caution since demand elasticities may differ from one area to another especially in small and medium sized urban areas as compared to large metropolitan areas. To test the models' transferability to a smaller urban area, application was made to specific market segments within Knoxville, TN. Three separate markets were tested where specific ridesharing programs had been implemented and results observed. The markets and applied strategies were: Union Carbide facilities in nearby Oak Ridge, TN, carpool matching and community wide vanpooling program; Knoxville CBD, carpool matching and community wide vanpooling program; and TVA headquarters in downtown Knoxville, carpool matching, employer vanpool and express bus programs, and employer financial incentives for vanpooling and express bus riders. Appendix E presents the step by step procedure and accompanying work-sheets for analyzing ridesharing options using the DOE manual method along with the three example applications for Knoxville.

Applying the analysis method to these three market segments resulted in both under and over estimation of observed modal shares. As seen in Table 6.9 predicted carpool and vanpool shares for the CBD and Union Carbide facilities were higher than observed shares while predicted shares were lower for TVA. The difference between the actual and predicted shares for these two groups can be linked to the intensity of the programs. In the case of Union Carbide and the CBD, a community wide program was introduced rather than the more aggressive employer based and managed ridesharing program at TVA. The strong employer commitment by TVA which included financial incentives, strongly influenced many employees to rideshare. On the other hand the

TABLE 6.9 MODE SPLITS FOR KNOXVILLE USING DOE MANUAL METHOD

	Knoxville CBD			Union Carbide									TVA		
				X-10			K-25			Y-12					
Mode	Base	Predicted	Observed	Base	Predicted	Observed	Base	Predicted	Observed	Base	Predicted	Observed	Base	Predicted	Observed
Drive Alone	54.7	48.7	54.5	37.4	27.5	35.0	37.8	27.8	35.5	53.8	43.4	51.5	65	52.5	15
Carpool	32.6	40.8	32.5	57.6	59.8	55.5	57.2	59.5	54.5	41.2	43.2	38.5	30	32.0	37
Vanpool	0.0	1.3	0.5	2.0	10.2	8.0	2.0	10.3	8.0	2.0	10.7	8.0	1	5.6	22
Transit	9.1	7.8	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3	9.9	26
Other	3.6	3.3	3.5	3.0	2.5	1.5	3.0	2.5	2.0	3.0	2.7	2.0	1	0.0	2

community wide program was more passive and did not generate the type of employer commitment and enthusiasm generated by TVA.

Through these applications it appears that the DOE model predicts mode shares somewhat higher than observed values when the program intensity is average and underestimates values for high intensity programs. In addition to the programs intensity playing a role in modal predictions the fact that model coefficients were calibrated for a large urban area (Washington, DC) and applied to a medium sized community may also contribute to the variation between predicted and observed results. It appears that elasticities of travel cost and presence of a ridesharing program may differ slightly between city size and the intensity and enthusiasm generated by the programs. Taking these factors into account, the DOE method can still provide useful mode split estimates but a careful analysis and slight adjustments of predicted values may be necessary to account for city size and program intensity.

Another important finding from these test applications is the introduction of vanpooling and transit services in areas where they previously did not exist. In all three test applications, vanpooling did not previously exist to a great extent and the models' method for introducing vanpooling is to estimate the expected mode share and subtract this additional proportion from the other modes to balance mode shares. Due to this subtracting of vanpool shares from other modes to represent diversion of riders, initial estimated vanpool proportions play a major role in the predicted shares of all modes. If the estimated vanpool share is too large, predicted proportions for other modes may be underestimated while the opposite could occur if

vanpool shares are initially too low. As a guide to estimating vanpool shares a community wide vanpool program would most likely not comprise more than five percent of the model share and an employer sponsored program without financial incentives could attract between 10 and 15 percent depending upon employee travel distances and employer commitment. In the case of Union Carbides' facilities in Oak Ridge, Tennessee, the observed vanpool share was only eight percent, even with a long commute distance (20 plus miles one way) and an actively marketed program. In the case of employer financial incentives for carpools, modal shares may readh 20 to 25 percent.

In the case of transit incentives such as reduced fares, predicted transit shares may be below observed results as was the case for TVA since the initial transit share was almost nonexistent. In situations such as this where initial transit proportions are low, predicted shares will usually also be low because predicted results are calculated by multiplying base shares by demand elasticities. Under these conditions, upward adjustments similar to those of estimated vanpool shares should be made to the base transit share so that predicted transit proportions more closely approach expected results.

Utilization of the DOE method can provide useful projections of expected modal proportions through careful estimates and analysis. Application to the three Knoxville market segments identified that slight adjustments are necessary to represent the level of program intensity and city size. In addition to these adjustments the introduction of new or upgraded vanpool and transit programs in areas of low usage, requires careful estimation of expected base shares and in the

case of transit incentives it may be necessary to adjust the base share upward to more closely estimate expected results.

Service Area Identification Methodology. The Service Area Identification Methodology (SAIM), was developed by the University of Illinois at Chicago Circle in 1977 under a DOT University Research grant (Soot, 1977). SAIM is a computer based methodology which analyzes the commuting pattern and number of commuter trips which potentially can be served by carpooling, vanpooling or park and ride/express transit service. The SAIM programs are not intended to be mode choice models but rather a "first cut" screening process designed to aid planners in making initial identification of areas in an urban region where one or more of these modes could be cost effective.

Market potential is based on travel time and travel cost algorithms in which each of the three modes is compared with the drive alone mode to determine which produces a better level of service. The SAIM program requires as data input an aggregated origin/destination trip matrix of the area under study, with each aggregation unit having (X, Y) coordinates. The model was originally developed with 1970 census journey to work trip data for the Chicago Metropolitan Area, but data from urban transportation planning O-D surveys or synthetic estimates derived from employer surveys or land use data could be utilized. In any case the (X, Y) coordinates of each analysis zone must be defined to conform with SAIM structure.

Output data from SAIM for each mode consists of three parts: (1) graphic representation of service area (maps) which locate various origins and destinations that can be served by a particular mode; (2)

summary tables of regional statistics, such as number of potential users, average trip length, distribution of trip lengths, etc., and (3) individual zone by zone listings of trips and number of trips which will potentially use the mode being considered.

The SAIM programs provide useful tools to planners in assessing ridesharing potential but entails some limitations for use in other areas due to the extensive data coding of each analysis zone.

Baltimore vanpool model. The Baltimore Region Planning Council developed a sketch planning approach to forecast the impacts of a regionwide vanpooling program (Baltimore, 1977). The method utilizes aggregate planning data to calculate the potential number of vanpools that could occue given the travel movements of the area. The major data items of the methodology were trip origins and destinations in 145 internal and 20 external traffic districts, and the size of employers in each district. Key assumptions of the model include: (1) vanpooling is considered feasible only for peak period work trips which represent approximately 23.6 percent of total weekday VMT; (2) each vanpool is expected to replace about eight automobiles and carry 10 occupants; (3) the minimum oneway trip length for vanpools must be greater than nine miles, these trips represent about 60 percent of all auto work trips and 82 percent of peak period work trip VMT; (4) vanpools would be promoted at employers who employ more than 200 persons, work trips for commuters working for employers with at least 200 employees and traveling nine miles or more represent 42.9 percent of peak period work trip VMT; (5) the maximum capture rate of potential vanpoolers was

assumed to be 25 percent of those commuters who fell into the previously defined categories. Thus, since 60 percent of the work trips are nine miles or greater, the 25 percent capture rate translates into an overall capture rate of 51 percent.

The methodology was applied to both 1975 and 1985 area wide travel estimates and results are shown in Table 6.10. The results indicate that the maximum potential for VMT reduction due to vanpooling is nearly 8 percent of peak period work trip VMT and 3 percent of total daily VMT. These vehicle trips which shifted to vanpools were then assigned to the highway network, and resulted in traffic volume reductions averaging nearly 10 percent on major radial and circumferential corridors.

In the initial analysis no restraint was imposed on limiting the diversion of transit riders to vanpools and consequently 1.7 percent of the total daily transit ridership was diverted. To limit this diversion a revised strategy was incorporated into the methodology that prohibited vanpool service between any home-work pair of districts if current transit ridership exceeded a specified mode share.

The Baltimore methodology is a simple method of estimating vanpool potential and can be easily applied to specific regions of a community. Many of the assumptions such as the 9 mile commute distance, 25 percent capture rate, and the removal of eight autos per van are upper limits and consequently produce maximum potential estimates. The methodology could be easily implemented in most regions with adjustment to many of the factors to represent more reasonable estimates.

Highway network models. Highway network models which are typically a part of urban transportation planning studies can be useful tools in

TABLE 6.10 VMT IMPACTS OF AN EXTENSIVE VANPOOLING PROGRAM IN BALTIMORE MARYLAND

	Variable	Based On 1975 Estimates Of Travel[a]	Based On 1985 Estimates Of Travel[b]
a.	Total average weekday Vehicle-Miles-of-Travel (VMT)	30,699,000	42,835,000
b.	VMT in (a) made by work trips in the peak traffic periods	7,245,000	9,533,000
c.	VMT in (b) due to trips nine miles or more	5,941,000	8,110,000
d.	VMT in (C) due to large ($\geq$ 200 employees) employers	2,549,000	3,436,000
e.	VMT in (d) eliminated due to vanpooling (25% capture)	637,000	859,000
f.	Additional VMT saved by increased carpooling	363,000	461,000
g.	VMT added by vans	76,000	102,000
h.	Net daily VMT savings (e) + (f) -(g)	924,000	1,218,000
i.	Net VMT savings expressed as a percent of peak VMT	8.3%	8.0%
j.	Net VMT savings expressed as a percent of daily VMT	3.0%	2.8%
k.	Gasoline saved annually (gallons)	17,000,000[c]	19,000,000[d]

[a]The 1975 case would require 2,300 vans.

[b]The 1985 case would require 3,100 vans.

[c]Assumes 250 working days per year, 13 m.p.g. for autos, and 10 m.p.g. for vans.

[d]Assumes 250 working days per year, 15 m.p.g. for autos, and 10 m.p.g. for vans.

identifying locations for potential park and ride lots. Through the assignment of trips on the street network, locations (nodes) can be identified that have a large number of trips passing through them to a common destination. By specifying a minimum trip distance from the potential park and ride lot to the destination, modifications can be made to network programs to provide a record keeping system of the number of trips passing through a given node which meet the specified distance criteria. This information in turn can be a starting point for identifying park and ride lots based upon the volume of potential users passing that location.

Summary of methods for determining demand. From the previous review, existing methodologies can be divided into two distinct application groups, those that estimate mode choice and those that identify market segments by determining the number of commuters that possess certain common travel characteristics and thus are candidates for ridesharing. The three disaggregate mode choice models and the DOE method fall into the former group while the remaining techniques comprise the market identification group. The disaggregate models attempt to estimate the number of commuters who will rideshare as a result of transportation system changes while the remaining techniques identify market segments which have a high potential for ridesharing based upon travel cost, time, and distance characteristics. In this later group no estimate is made of the proportion of identified commuters who will rideshare, and an additional step must be performed to determine this value. Consequently, planners are faced with the task of selecting between disaggregate logit models which require extensive expertise,

the DOE manual method, of simplified market identification techniques that still leave the planner with the task of estimating expected rideshare proportions.

The application of the market identification techniques is recommended for the purpose of determining potential markets if a comprehensive and detailed analysis is desired. These techniques can be applied in the market identification phase (Step 3) of the planning guidelines which are discussed in detail in Chapter 7. Of the three techniques, the Baltimore method and modified highway network models are recommended as quick and straightforward means of identifying potential markets. Use of SAIM, while being more detailed, is not recommended since data preparation and greater program expertise result in increased costs which are normally not justified in medium and small communities.

Since both of the suggested market identification techniques require origin-destination trip data as the primary means of determining potential markets, some limitations may be placed on their use if O-D data is not current since quick updating is usually beyond the financial limits of most communities. For application in small and medium sized communities where O-D data is old, a visual inspection of the spacial separation between work sites and employee residences as well as peak period traffic patterns should enable identification of corridors with long commute distances and a large volume of common origins and destinations. In most cases this visual inspection is adequate in identifying potential markets in small and medium sized areas, but if a thorough detailed analysis is desired, the two suggested techniques can be applied.

Suggested Methods for Determining Demand

To provide quick and inexpensive demand estimates, three techniques are suggested: (1) application of the DOE manual method, (2) administration of local surveys to identified market segments, and (3) examination of previous strategy applications in other communities. The three disaggregate mode split models are not recommended, since their calibration, required technical expertise, and cost make them unsuitable for quick inexpensive analysis. Of the three suggested techniques, local surveys are recommended as the best technique for estimating demand since results are current and based on local community responses. The cost and time of administering such surveys is greater than the other two methods, but if resources are available the greater reliability justifies the cost. In situations where resources are not available for survey administration, or strategies are politically sensitive such as parking bans or taxes and it is desired to avoid possible public criticism which may arise through local surveys, the DOE method and results from previous strategy applications will provide adequate estimates of ridesharing proportions. When utilizing the DOE method, it is suggested that comparisons be made with past strategy applications to assess the magnitude of mode shares since test applications showed deviations from observed results. Further discussion on estimating expected demand is presented in the detailed evaluation section of Chapter 7 along with a listing of observed results from application of strategies in various communities.

CHAPTER VII

MARKET IDENTIFICATION AND STRATEGY EVALUATION

The major elements in selecting ridesharing strategies as outlined in the guidelines involve that of market identification, preliminary and detailed evaluation, and strategy selection. In these phases of the planning guidelines, Steps 3 through 6, target market segments within the study area are identified and matched with potential strategies (Step 3), evaluated as to their overall effectiveness in influencing new ridesharing arrangements and ease of implementation (Steps 4 and 5), and combined into a final group of desired strategies (Step 6).

As a guide in performing this analysis, Chapter VII is divided into four sections addressing Step 3 through 6 respectively of the guidelines. In each section a discussion of each evaluation factor is presented as well as appropriate summary tables for quick reference use. The final section, Strategy Selection Step 6, suggests methods for final selection of strategies such as economic efficiency analysis and scoring methods.

Market Identification

The initial step in selecting ridesharing strategies is to identify market segments that are capable of supporting alternative strategies. Market segments in this context refers to groups of commuters with similar travel and socioeconomic characteristics or areas within the community that possess characteristics necessary for application of a particular strategy. Based on this definition, market segments for example could be a group of commuters with a oneway travel distance

greater than 15 miles, an area within the community where the demand for parking exceeds supply, or a heavily traveled corridor with a large volume of common origins and destinations. In these examples, strategies which would be applicable to each market segment are vanpooling, parking management techniques and preferential lanes respectively. Thus by identifying potential market segments through commuter or community characteristics, each strategy can be evaluated as to its potential application in the study area based upon common characteristics.

For most strategies to reach their greatest potential, certain characteristics must exist within the area of application. In the case of parking management techniques, parking demand should exceed supply while preferential lane use requires a corridor with a large volume of common origins and destinations. This is not to say these strategies will be successful in these areas or that they would not be applicable in other areas, but rather indicates that the greatest potential exists in these areas and further more detailed evaluation is necessary before a final conclusion can be reached. In identifying potential segments the primary emphasis is directed at community rather than commuter characteristics since the success of a particular strategy is primarily dependent upon the surrounding environment and the fact that few differences exist between solo drivers and ridesharers in terms of socio-economic and travel characteristics (Mangolin, 1978).

To aid decision makers in performing a market analysis, a list of "Market Identification Factors" has been complied and is contained in Table 7.1. The list summarizes important market characteristics to be

considered and can be utilized as a check list when identifying markets. Through use of these factors, an organized and comprehensive analysis can be undertaken to assess the potential of each strategy to the study area. This in turn provides a starting point for further evaluation and the combining of strategies into a comprehensive ridesharing program.

Utilizing the identification factors of Table 7.1, a familiarity with the market characteristics of each strategy is a helpful starting point since market identification would be difficult if one was unfamiliar with the strategies. Table 7.2 summarizes market characteristics for each strategy and should be utilized in conjunction with Table 7.1 as a quick reference of market characteristics. As a further aid in identifying market segments, a discussion of the important considerations of each identification factor is presented.

High density employment centers. Areas of high employment in most instances have the greatest potential for ridesharing activities since the number of commuters with common origins and destinations is usually the greatest. These areas also enable a large number of commuters to be contacted with minimal effort. As a result, carpool and vanpool programs are especially suited for these areas as well as other supportive strategies which rely on matching techniques for greater effectiveness. Large employment centers may also possess parking and congestion problems which could lead to the application of financial incentives, parking management techniques, and flexible work hours. Even though these supportive strategies are more effective with strong

TABLE 7.1 RIDESHARING MARKET IDENTIFICATION FACTORS

High Density Employment Centers
High Density Resential Areas
Commuter Travel Distances
Heavily Traveled Corridors
Areas of Severe Traffic Congestion
Areas of Low Parking Supply
Working Habits

TABLE 7.2 MARKET CHARACTERISTICS BY STRATEGY

Strategy	Market Characteristics
1. Carpool Matching Programs	Community wide matching programs: medium and large urban areas; Site specific matching programs: single large employers or concentration of large volume of employees (greater than 500 employees).
2. Vanpool Programs	Large single employers or concentration of employees (greater than 500 employees); One way travel distance greater than 15 miles; No particular type of occupation is more desirable. Employer parking problems are valuable incentive.
3. On Street Parking Restrictions	Parking demand exceeds supply; large employment centers (CBD) or other areas where on street parking is permitted and demand exceeds supply (hospitals, universities).
4. Off Street Parking Restrictions	Parking demand exceeds supply; areas were new development is occurring or expected (restrictions in new parking supply).
5. Residential Parking Control	Residential areas within walking distance of CBD or other large employment center where spill over parking occurs (hospitals, universities).
6. Exclusive Bus/Carpool Lane Arterial	Large volume of common origins and destinations; Corridors with bus volumes of 20-25 per hour; Minimum of 5 travel lanes; Length varies based on travel time savings.
7. Contra-Flow Bus/Carpool Lane	Large volume of common origins and destinations; Arterial streets with minimum of 5 travel lanes and bus volumes of 20-25 per hour; Freeway bus volumes of 40-60 per hour.
8. Reversible Lane Systems	Same as strategy No. 6
9. Freeway Bus/Carpool Bypass	Large volume of ramp traffic. Metered on ramps.
10. Exclusive Bus/Carpool Lane Freeway	Large volume of common origins and destinations; Corridors with bus volumes of 40-60 per hour.
11. Special Bus/Carpool Turning Privileges	Areas of severe traffic congestion and resulting travel time savings.
12. Vehicle Tolls	Existing toll facilities.
13. Carpool/Vanpool Preferential	High demand for parking; Excessive walking distance from parking lot; Large employment sites.
14. Parking Rate Changes	Areas where land values and parking rates are high (CBD).
15. Park and Ride Facilities	Existing bus transit park and ride lots; heavily traveled corridor with single destination; large remote employment centers with one-way commute distance greater than 10 miles; high parking cost at destination and low supply.
16. Elimination of Employer Parking Subsidies	Applicable to any type or location of employer. Greatest potential at sites where land availability is scarce or employer is desiring to expand physical plant.
17. Employer Financial Incentives	Employers active in ridesharing, high parking costs, high demand for parking.
18. Auto Free or Restricted Areas	Downtown areas, one or two streets usually converted to shopping mall.
19. Staggered or Flexible Work Hours	Large single employers or concentration of employees; white collar employment centers; areas with severe congestion problems.

matching support, the presence of these other characteristics is essential to their operation and must be considered before a conclusion can be made. For example, most parking management strategies while being aided by carpool matching will not be effective if parking is readily available.

High density employment centers which are commonly found in urban areas include single large employers, industrial and office parks, regional activity centers, and the central business district. Large shopping centers while employing a large number of employees, do not exhibit the same working characteristics as the previously mentioned sites because of the large number of part-time workers and irregular working hours. As a result, ridesharing programs have experienced little success at these locations and consequently are not considered in the same scope as other density populated work sites.

High density residential areas. High density residential areas like densily populated employment centers have a greater potential for a large number of commuters with common origins and destinations and consequently are target markets for carpool and vanpool programs. These areas also enable easy contact of a large number of commuters through neighborhood groups or apartment associations. High density residential areas would most likely be large single apartment buildings or areas with a clustering of multifamily dwelling units. The primary reason for identifying these high density residential areas is to enable marketing of matching programs to the greatest number of commuters with the least amount of resources.

Commuter travel distances. As discussed in previous chapters, the incentive to rideshare is substantially greater for those commuters who have longer home to work travel distances. Through identifying areas with longer commute distances, program resources can be directed at these areas initially since the greatest potential for forming ridesharing arrangements exists in these areas. This in turn enables a ridesharing program to grow visibly and builds momentum for addressing areas with less potential or reluctance to participate in program activities. Strategies which might be applicable to these areas include carpool and vanpool programs, preferential lanes, and park and ride facilities.

The distance at which ridesharing becomes attractive is relative to the commuting characteristics of the community. If the study area is small and commute distances are short, a shorter distance will provide an incentive to rideshare than if the commute distances were longer. From Chapter IV commute distances for ridesharers averaged 23 miles in Los Angeles, California, while ridesharers in Knoxville, Tennessee, travel an average of 11 miles oneway. In the case of vanpooling, the oneway commute distance should be greater than 15 miles to maintain a competitive fare structure with driving alone. Areas that exhibit longer commute distances can be identified by utilizing the Baltimore Technique discussed in Chapter VI which utilizes existing origin-destination data from urban transportation studies or modification of existing highway network models. Through use of these techniques the number of trips exceeding a specified trip distance are determined and in turn, used to identify locations for intensive ridesharing promotions. In cases where such a detailed analysis is not

desired due to cost and time restraints or existing origin-destination data is not current, a visual inspection of employment and residential areas can be made to observe areas where commuter distances are long and origins and destinations common. Longer commute distances can be determined by identifying remote employment and residential areas or suburban subdivisions that are located beyond the distance which makes ridesharing attractive in the study area. In many communities, especially small and medium sized areas, it can quickly be determined that a majority of employees at certain plants or firms live in close proximity to one another. For example, many white collar workers in the CBD tend to live in more influential suburban neighborhoods while shift workers at manufacturing plants may live in older areas of the community.

Heavily traveled corridors. Corridors which carry a large volume of traffic to common destinations such as the CBD may be potential candidates for preferential lanes, park and ride facilities, and carpool and vanpool programs. To justify a reserved lane, the corridor must carry a greater number of people than carried prior to reserving the lane. In most instances a preferential lane for carpool and vanpool use only would not be capable of generating this demand and consequently must be implemented in conjunction with substantial express bus service. Suggested demand for a reserved bus, carpool, and vanpool lane on a freeway ranges from 40 to 60 buses per hour carrying from 1,600 to 2,400 passengers per hour as a minimum (NCHRP, 1975). Suggested demand on arterial streets is 20 to 25 buses per hour. In the case of arterial streets, a minimum of five lanes, one being the

reserved lane must be available to avoid congestion as a result of an accident or stalled vehicles in the nonreserved lane. The length of reserved lanes can vary from one-half mile to greater than 10 miles with the major consideration being the resulting travel time savings. Thus reserved lanes can be located on heavily traveled corridors at areas of severe congestion such as interchanges and intersections, or other areas where congestion occurs. In identifying these corridors traffic volumes must not only be large but also be destined to a common area. If trip destinations are diffused along the corridor, reserved lanes become less effective because commuters travel less distance on the lane and experience a smaller travel time savings. Park and ride facilities also become less effective since trip distances are usually shorter which reduces the incentive to rideshare. Other corridors which might exhibit these high volume characteristics may lead to regional activity centers or other large employment centers. In most instances, reserved lanes would not be warranted due to the minimum bus volumes but park and ride facilities with computer matching may be applicable along these corridors.

Areas of severe traffic congestion. Areas where severe traffic congestion occurs may be prime locations for the application of isolated priority techniques such as short length reserved lanes or special turning privileges. Signal preemption while being practical for buses has limited application to carpools and vanpools because of the constant stopping of buses at the signals.

Areas where these techniques might be applicable include the CBD, industrial and office parks, large employers and areas where turns are

prohibited during rush hour. For each application to be successful travel time savings or relief from congestion should be substantial enough to influence commuters to rideshare. These measures are relative to conditions in each community and consequently should be determined through travel times and congestion levels within each study area.

Areas of low parking supply. In areas where the demand for parking exceeds available supply, a number of parking management techniques may be applicable. Areas most likely to exhibit a shortage in parking are high density employment areas such as the CBD, regional activity centers, university areas, or industrial and office parks and large single employers. Parking techniques which are directly applicable to areas of low supply include elimination of employer subsidies, increase in parking rates, parking surcharge tax, and preferential carpool/vanpool parking. In many instances complementing parking strategies must also be implemented to eliminate alternative, less costly or more attractive parking spaces. These strategies include elimination of on-street parking, and residential permit systems.

For parking strategies to become successful an alternative mode of travel must be readily available to commuters. If transit coverage is poor and ridesharing programs nonexistent, parking strategies will encounter public objections and most likely failure. Therefore, an area must possess or have the capabilities of developing a strong transit and ridesharing program before parking strategies are implemented. In most instances parking rate increases and taxes are limited to areas where charges are presently made for parking such as the CBD.

Elimination of employer subsidies and preferential parking can be applied to most high density locations. The key factor to consider in these strategies is to eliminate alternative sources of parking. If an employer decides to eliminate parking or reduces the number of spaces, other nearby sources should also be eliminated if possible (on-street parking, parking in residential areas) and an alternative mode of travel should be available. As a result of the condition that an alternative mode be made available, strategies that eliminate or raise parking rates are applicable to large employment areas that are served by transit or have the potential for transit service. Preferential parking is applicable at sites where demand exceeds supply or locations where close in parking reduces walk time or is sheltered from adverse weather. In most instances these are also areas where demand exceeds supply. Employer size is less critical in the case of preferential parking, but in most cases small work sites do not experience parking problems and preferential spaces would provide little incentive.

Working habits. In examining areas of a community, employee work habits are important considerations in identifying potential markets and applicable strategies. The general nature of the work forces and their working hours can influence the success of several strategies. Areas or employers that are production oriented and dependent upon others for the accomplishment of their work task are not well suited for flexible work hours. In general white collar employment centers are best suited for flexible work hours since employees are less dependent upon others and able to manage their time more freely to coincide with others for pooling. Flexible work hours may be applicable at

manufacturing industries in certain cases and a closer analysis of the nature of work may be necessary to fully assess its potential.

If overtime work is substantial and unpredictable, matching programs may be less desirable since pooling arrangements would be difficult to maintain. Employers which employ a large number of part time employees or where shifts are split or rotating are also less suited for matching techniques since it is difficult to coordinate work hours and days for those pooling. A prime example of employers which exhibit these latter characteristics are retail sales shops.

Toll facilities. Existing toll facilities such as bridges, tunnels, ferryboats, and toll roads should be identified in order to assess the possibility of providing preferential treatment or reduced tolls for ridesharers. If congestion occurs at toll plazas, preferential lanes on the approach road or reserved lanes on the facility may substantially reduce travel time for ridesharers. Ridersharers could also be given reduced or free tolls on the facility.

Preliminary Evaluation

After market segments have been identified and candidate strategies selected, a preliminary first cut evaluation of each alternative is undertaken. The orientation in this first cut analysis is toward narrowing the range of strategies for detailed evaluation to those best suited to the study area. Eliminating unacceptable strategies based on noncapability with community goals and transportation programs or lack of political or public support enables a streamlining of the evaluation process and concentration of resources to the most promising strategies. To perform this preliminary analysis each potential strategy is

assessed against several major considerations which function as a checklist to insure that nonconforming strategies, or ones with major implementation obstacles are eliminated prior to detailed evaluation. In many instances where the study area is small and the number of alternative strategies few, preliminary evaluation will most likely be performed in conjunction with market identification. In any event, the following checklist of preliminary evaluation measures should be assessed against each strategy in the early stages of selection to avoid needless analysis of unacceptable strategies. Evaluation measures which should be considered include:

- o Compatibility with community goals and objectives;
- o Compatibility with current or proposed transportation programs;
- o Political and Public acceptability;
- o Availability of financial resources; and
- o Identification of supporting strategies.

To emphasize the usefulness of these measures in screening strategies a discussion of each follows.

Compatibility with community goals and transportation programs. To gain successful backing by community leaders and residents, strategies should be compatible with the goals and transportation programs of the area. If strategies conflict with goals or are counter productive to existing or proposed transportation programs, extensive conflicts could arise which may jeopardize the success of any type of ridesharing activity. In many instances valuable resources of time and money can be devoted to developing detailed implementation programs for strategies which from the outset were unacceptable.

Community goals in most instances are broadly defined to include most ridesharing strategies. As a result, conflicts are less likely to arise concerning compatibility with goals and objectives. The major area of potential conflict arises when existing or proposed transportation programs are considered. Ridesharing strategies can be in direct conflict with other transportation programs which in the implementation stages could initiate adverse public reaction toward ridesharing. An example of this situation can occur when vanpooling is implemented in a heavily traveled corridor that is presently served by express bus service. Vanpool implementation in this instance without considering express bus service could cause a diversion of riders from transit and place the continuation of bus service in jeopardy. Under these conditions the two services should be closely examined and a decision made to determine which should be given priority. Vanpooling can be compatible with express bus service if designed to serve areas not within the existing express bus service area or to relieve overcrowding on those runs where additional service would not be financially justified.

In addition to transportation programs, strategies should consider other improvement projects or policies which might affect their success. Several parking management strategies, especially incentives for carpool and vanpool parking could experience marginal success if the community is substantially increasing parking supply. The greater availability of parking could be counter productive to ridesharing unless restrictions were placed upon these new spaces to make them less attractive to all day commuters.

Political and public acceptability. An essential element in the final selection and success of many projects is the degree of favorable support they receive from political decision makers and other influential community leaders. Several ridesharing strategies such as parking bans or increased taxes can easily meet rejection from community leaders and decision makers. Even in the case of less restrictive and changing strategies such as preferential parking or financial incentives, programs which alter common everyday commuting habits can experience quick failure if favorable community and political support is absent. In situations where community leaders oppose a strategy, decision makers are often faced with a politically sensitive decision that can result in the strategy receiving little or no supportive backing, even though the program is favored by them. As a result of this need for supportive backing, initial screening procedures should assess the level of potential acceptability for each strategy from both community leaders and decision makers. It is important that reactions from both groups be considered since the two may express different opinions and their influence on one another may affect decisions in later stages of selection and implementation.

In addition to assessing acceptability, sensitive issues concerning each strategy can also be identified and used in modifying strategies to increase their acceptability. For example, in the case of financial incentives, if the proposed level of employer support is high, employers may object and suggest a lower more acceptable level. In the case of other strategies such as parking bans or taxes, retail merchants may completely oppose strategies that prohibit parking in the

area which may cause a reduction in retail sales. Attitudinal assessments early in the selection process enables planners to avoid initiating negative reactions toward strategies that are often drawn out of proportion and consequently make it difficult to modify otherwise acceptable strategies. It also attempts to eliminate the possibility of creating a negative atmosphere toward any type of present or future ridesharing program.

To quickly assess political acceptability, planners should draw upon previous experience with similar strategies or projects. If similar projects have met with opposition or failure, it is doubtful current attitudes have changed unless considerable changes in the community have taken place. In cases where past experiences cannot be drawn upon, planners can attempt to identify attitudes by proposing strategies to community leaders and decision makers on an informal basis.

Availability of financial resources. In formulating ridesharing programs like other community projects, the availability of financial resources is critical in determining its scope and intensity. Identifying the availability and level of funding serves a dual role in developing and selecting strategies. First, it focuses the selection process on those strategies which are within the financial bounds and secondly, it identifies if limitations should be imposed on the scope of individual strategies to reduce their cost. Strategies such as preferential lanes or community wide matching services can become extremely expensive and beyond the financial capabilities of many

communities. In the same light, the entire magnitude and comprehensiveness of program services can result in escalating costs. As a result the selection process should initially investigate the ability to finance strategies and disregard those that are too costly. Likewise the scope and intensity of individual strategies may be adjusted so that costs may fall within financial limits. For example, in the case of computer matching, or vanpool programs, community wide application might result in excessive costs while a reduction to selected market areas within the community could substantially reduce costs while still maintaining an acceptable level of effectiveness.

Identifying financial resources can be approached from two ends, either determining the availability of local funds or investigating sources of state and federal funds. The level of funding for either of these sources is dependent to some degree on each other. In some situations the availability of federal or state funds will free up local matching monies that would otherwise not be available. This is especially true in the case of demonstration or special project funds. On the other hand, the presence of local matching funds may encourage a greater use of federal and state monies if available.

In most communities, several sources of funding are available for various ridesharing projects, but are in direct competition with other transportation projects that utilize these same funds. In the case of federal aid highway funds, ridesharing projects can utilize primary, secondary, or urban systems funds on a 75-25 match, but must compete with highway and traffic engineering projects for this same money. As a result of ridesharing's low priority, little if no money is allocated from these sources.

Financial resources can be combined from a variety of sources for ridesharing and as a result, a thorough investigation should be undertaken of all available sources. Since funding sources for ridesharing strategies are changing rapidly, assistance in determining the latest sources and their extent should be solicited from FHWA and UMTA regional offices as well as the local state department of transportation. Combining these various sources of funding and identifying their limitations provides an estimate of total expected resources and the level of financial commitment required by the local government. This funding level can then become a guide in selecting financially feasible strategies.

Identifying supportive strategies. As a final step in preliminary strategy selection, a review of remaining strategies should be undertaken to identify if the inclusion of supporting strategies will enhance the effectiveness of the total ridesharing program. In many situations supporting strategies are essential to the success of other strategies and should be implemented to produce a strong incentive for ridesharing. For example, in the case of preferential parking for carpools and vanpools, some type of matching program is essential to provide a means of forming new ridesharing arrangements and successful utilization of reserved parking spaces. Similarly, if parking bans are imposed, supporting strategies to eliminate alternative parking spaces and matching programs to encourage ridesharing are necessary for successful results.

Besides identifying essential supporting strategies, other complementary ridesharing actions should be evaluated to assess their

applicability toward existing strategies. As additional ridesharing experience is gained through preliminary evaluation steps, strategies which were initially rejected or overlooked could be reconsidered and included for further detailed evaluation.

In comprising a ridesharing program, any group of strategies can be combined without fear of counter productive results since strategies do not directly compete with one another. In certain situations competition does exist to some extent between strategies as in the case of carpooling and vanpooling where vanpools may divert riders from carpools. In this situation, the net effect is a continued utilization of a ridesharing mode since riders are diverted from one ridesharing mode to another. The inclusion of additional strategies in many cases may not directly increase the effectiveness of other strategies but should enhance the overall incentive to rideshare.

The primary emphasis in combining strategies is to identify supporting actions which are essential to the success of a particular strategy or theme and include other supportive actions which are within the scope and resources of the program. If parking management is a major action in a ridesharing program all appropriate strategies such as residential parking permits and on-street parking restrictions should be assessed in the selection process to determine their applicability and contribution to the program. Failure to evaluate and include one or two supporting strategies may weaken the effectiveness of the entire action and stimulate little interest in ridesharing.

Identifying essential supporting strategies requires a familiarity with the characteristics of each strategy which is usually obtained through literature reviews of implemented strategies or contact with

project operators. As a quick reference, Chapter 3 presents a short description of each strategy and identifies supporting actions which enhance the incentive to rideshare. For effective implementation of each ridesharing strategy some form of commuter matching service, either manual or computer is essential to provide commuters a means of forming new ridesharing arrangements. Providing an incentive to rideshare while leaving commuters on their own to solicit ridesharing partners, results in only a few aggressive commuters forming new pools. The remaining majority become frustrated with the inability to find pooling partners and in many instances develop negative attitudes toward ridesharing. These negative attitudes can in turn jeopardize the success of future ridesharing or transit programs since individuals have experienced poor previous programs.

Besides supportive matching programs, other strategies except parking management actions, can be implemented without supportive actions while still maintaining a reasonable level of anticipated success. For effective implementation of parking management strategies that limit or restrict the number of available parking spaces in an area, alternative parking spaces such as on-street and nearby residential parking must be controlled to eliminate the diversion of commuters into these areas. Other strategies such as preferential lanes or preferential parking while implementable individually, are most effective when combined with supportive strategies such as park and ride lots and financial incentives respectively.

In addition to identifying supporting strategies this review can also be used to evaluate the successfulness of strategies in the event supportive actions are not implemented due to financial or political

reasons. Under these conditions, an assessment should be made to determine if remaining strategies can be effective without supportive actions. If the expected level of new ridesharing arrangements is low and costs high, the deletion of these strategies may be desirable so that available resources can be applied toward those strategies with the greatest potential..

Detailed Evaluation

The final stage in strategy evaluation is to perform a detailed analysis of remaining candidate strategies. Through preliminary screening, a list of possible strategies was narrowed to include only those that coincide with identified market segments and which presented no major obstacles to successful implementation. The objective in this detailed analysis phase is two fold, first it enables a close examination of expected impacts and institutional issues which may arise, and secondly it identifies quantitive and qualititive measures of costs and benefits which can be expected to occur.

To perform this detailed strategy evaluation the following measures should be considered:

- Legal and Regulatory Issues;
- Impacted Community Groups;
- Implementation Time;
- Program Costs; and
- Estimated Demand.

Through assessing each strategy against these measures, specific costs, benefits, and impacts can be determined, which in turn, become the basis for strategy comparison and final program selection. In addition

to being used for final program selection, these results provide a means of determining if strategy modifications would enhance their effectiveness. Just as modifications are made in response to preliminary evaluation results, so are adjustments undertaken after detailed analysis. Estimating program costs and impacts may suggest alternative strategy forms which may result in cost reductions or resolve critical impacts to acceptable implementation levels.

As an output of assessing these evaluation measures, a list of final candidate strategies should be assembled which have been closely screened to ensure their applicability to the study area and absence of major implementation barriers. To emphasize the usefulness of these evaluation measures a discussion of each is presented which identifies specific impacts and institutional issues, and provides quantitative values for program costs, expected demand, and implementation time for each strategy.

Legal and regulatory issues. Legal and regulatory problems concern the passage or modification of ordinances and regulatory actions that enable legal implementation of strategies. Strategies such as parking controls may require revisions to existing municipal ordinances while vanpooling may require deregulation by the state public service commission. Legal and regulatory problems may vary from state to state and even from city to city as regulatory structures and state and municipal statutes vary. Thus, each application must consider local conditions when addressing these issues. Table 7.3 identifies possible problems that may be confronted for each strategy and is broken into five groups of issues.

TABLE 7.3 LEGAL AND REGULATORY ISSUES BY STRATEGY

Strategy	New or Revised Municipal Ordinances	State Regulatory or Legal Enabling Legislation	Insurance Issue	Employee Labor Agreements	Changes in Municipal Building Costs	Transit Agreements/ Arrangements
1. Carpool Matching Programs			Increases or decreases in rates for those ride-sharing	Possible Inclusion as employee fringe benefits and labor agreements		Inclusion of transit information on matching lists
2. Vanpool Programs		Deregulation of vanpools by State Public Utilities Commission	Establishment of insurance classification and rates	Same as Strategy No. 1		13(c) Agreements.
3. On Street Parking Restrictions	Legal authority to restrict parking by municipal government					Coordination of transit routes with parking restrictions, availability of transit capacity to handle additional riders
4. Off Street Parking Restrictions	Same as Strategy No. 3	State enabling legislation			Legal authority to limit parking space requirements for new buildings	Availability of transit capacity to handle additional riders

TABLE 7.3 (Continued)

Strategy	New or Revised Municipal Ordinances	State Regulatory or Legal Enabling Legislation	Insurance Issue	Employee Labor Agreements	Changes in Municipal Building Costs	Transit Agreements/ Arrangements
5. Residential Parking Control	Same as Strategy No. 3	Same as Strategy No. 4				Same as Strategy No. 4
6. Exclusive Bus/Carpool Lane: Arterial	Legal authority to enable reservation of exclusive lanes by ridesharing modes from local municipality	Legal authority to enable reservation of exclusive lanes by ridesharing modes from state DOT or legislature				Coordination of transit services on corridor
7. Contra-Flow Bus/Carpool Lane	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6
8. Reversible Lane Systems	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6
9. Freeway Bus/ Carpool Bypass	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6
10. Exclusive Bus/ Carpool Lane Freeway	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6
11. Special Bus/ Carpool Turning Privileges	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6
12. Vehicle Tolls	Legal authority to change or charge tolls	Legal authority to change or charge tolls				Same as Strategy No. 6

TABLE 7.3 (Continued)

Strategy	New or Revised Municipal Ordinances	State Regulatory or Legal Enabling Legislation	Insurance Issues	Employee Labor Agreements	Changes in Municipal Building Costs	Transit Agreements/ Arrangements
13. Carpool/vanpool Preferential Parking				Same as Strategy No. 1		Coordination with available transit services
14. Parking Rate Changes	Legal authority to change rates by local municipality					Same as Strategy No. 4
15. Park and Ride Facilities	Legal authority to enable parking facilities and contracts for joint use lots		Liability at parking facilities			Same as Strategy No. 13
16. Elimination of Employer Parking Subsidies				Possible issue in labor negotiations		Same as Strategy No. 13
17. Employer Financial Incentives				Same as Strategy No. 1		Same as Strategy No. 13
18. Auto Free or Restricted Areas	Legal authority to restrict traffic					Same as Strategy No. 13
19. Staggered or Flexible Work Hours				Same as Strategy No. 1		Same as Strategy No. 13

In reviewing Table 7.3, issues range from somewhat noncontroversial which allow the operation of park and ride lots to controversial time consuming arrangements such as 13(c) agreements with local transit operators. In identifying these legal and regulatory issues, information collected as part of the preliminary evaluation stage concerning political and public acceptability can be of aid since some institutional issues play a major role in determining political and community acceptance.

Determining institutional issues and the level of effort necessary to correct them is critical to final selection and programming of strategies. If issues are too cumbersome or political pressures too great to be realistically overcome, associated strategies can be eliminated from further consideration. If, on the other hand, reforms and agreements can be anticipated but an extended time period is necessary for negotiations, these strategies can be included for further analysis with the understanding that they be programmed for later stages of the ridesharing program. Programming strategies which face lengthly negotiation periods initially or early in a program, may result in implementation delays. This in turn causes commuters and decision makers to grow impatient for results and leads to the development of negative attitudes toward ridesharing which can affect the success of other strategies or future programs. Early identification of issues also enables strategy adjustments to be made in hopes of overcoming serious issues and reducing the time period for negotiating agreements.

Impacted groups. Identifying community groups which may be affected by ridesharing strategies and the type of expected impact plays an important role in strategy selection and emphasis. If

candidate strategies are expected to cause severe negative impacts, their initial deletion may be desirable to avoid jeopardizing the success of other ridesharing efforts as well as future application of the strategy. Determining potential impacts is also useful during implementation since project staff can anticipate negative impacts and be prepared with alternative actions. For example, in the case of vanpooling in a corridor with express transit service, a high potential exists for diversion of transit riders causing problems with transit operators. Through recognizing this problem from the outset, an assessment of the impact can be made in conjunction with the transit operator to determine if the service should be initially implemented or programmed later after evaluating vanpool operations in other areas of the community.

In addition to identifying negative impacts, many positive attributes are associated with ridesharing which are essential in developing political and community acceptance. Expected benefits which are associated with the application of all strategies include: reduced energy consumption, pollution reductions, increased utilization of existing roadways as well as eliminating the need for building additional facilities, reduction in required space for employee parking which enables better utilization of the work site for production, reduced absenteeism, and increased employee morale. In many cases, each strategy also has the potential to stimulate specific benefits to the community and various groups. For example, property taxes may increase as a result of better utilization of the work site, parking management strategies may increase the attractiveness of short-term parking and shopping in the CBD and in turn increase retail sales and sales tax

collections, and overcrowding may be relieved on express buses through vanpooling. Table 7.4 lists expected impacts for each strategy for six frequently affected groups. The impacted groups include: nonusers, transit services, employers, retail merchants, shoppers, municipal costs, and other impacted groups or impacts. Expected impacts both positive and negative for each strategy are identified for each group. Impacts listed are those specific to the strategy and groups and not general impacts such as reduced energy consumption or freeing up parking spaces. These general impacts are associated with each strategy and therefore omitted from the table.

Implementation time. The timing and scheduling of ridesharing strategies has two dimensions. First, the time period required to implement a particular strategy which is dependent upon the complexity of the strategy and the incremental time period for planning, design, and construction. Second, is the period after implementation where commuters adjust to the new conditions and modal changes are made. Estimating expected implementation and adjustment periods enables selection of strategies which fall within the program time frame.

Table 7.5 lists expected implementation times for each ridesharing strategy. The range in time spans for each strategy corresponds to the level of intensity, with application in small cities or selected small market segments usually requiring the lower range of time. In most situations ridesharing strategies can be implemented in relatively short time spans of less than six months. Exceptions to this are large construction related strategies such as preferential lanes or some

TABLE 7.4 RIDESHARING IMPACTS BY AFFECTED GROUPS

Strategy	Nonusers	Transit Services	Employers	Retail Merchants	Shoppers	Municipal Costs	Other Impacts
1. Carpool Matching Programs		Possible diversion of riders	Administrative cost; liability in case of accident	Increase sales since commuters are less able to shop in other areas	Increase parking spaces	Administrative cost of program	
2. Vanpool Programs		Diversion of riders	Administrative cost; liability in case of van accident		Increase number of parking spaces	Administrative cost of program	
3. On Street Restrictions	Reduce number of parking spaces	Better movement for buses. Increase incentive to use transit		Increase attractiveness of shopping in the area	Increase short term spaces	Reduce parking revenues if parking is eliminated. Increase revenue if short term parking is available	
4. Off Street Parking Restrictions	Reduce number of parking spaces	Increase incentive to use transit		Increase or decrease attractiveness of location	Increase or decrease number of parking spaces	Same as Strategy No. 3	

TABLE 7.4 (Continued)

Strategy	Nonusers	Transit Services	Employers	Retail Merchants	Shoppers	Municipal Costs	Other Impacts
5. Residential Parking Control	Reduce number of parking spaces	Increase incentive to use transit				Administrative cost of program	
6. Exclusive Bus/ Carpool Lane Arterial	Decrease travel time if usage is high; Increase travel time if usage is low; Prohibit turning movements	Decrease transit travel time; Divert transit riders		Decreases access to fronting stores; Loss of onstreet parking	Decrease access to abutting land uses; Loss of on-street parking	Capital maintenance, and enforcement costs	Increased traffic on alternate routes
7. Contra-Flow Bus/Carpool Lane	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6	
8. Reversible Lane Systems	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6	
9. Freeway Bus/ Carpool Bypass	Slightly increase travel time	Same as Strategy No. 6				Same as Strategy No. 6	
10. Exclusive Bus/ Carpool Lane Freeway	Same as Strategy No. 6	Same as Strategy No. 6				Same as Strategy No. 6	

TABLE 7.4 (Continued)

Strategy	Nonusers	Transit Services	Employers	Retail Merchants	Shoppers	Municipal Costs	Other Impacts
11. Special Bus/ Carpool Privileges		Same as Strategy No. 6				Same as Strategy No. 6	
12. Vehicle Tolls	Objection to toll increases	Diversion of transit riders				Reduce revenues ability to meet bond payments	
13. Carpool/ Vanpool Preferential Parking	Increased walking distance		Administration of program				
14. Parking Rate Changes	Increase parking rates	Same as Strategy No. 4		Same as Strategy No. 4	Same as Strategy No. 4	Increased tax revenues or decrease in revenues if demand decreases	
15. Park and Ride Facilities	Increased parking at work destination	Possible diversion of riders with matching from lots		Increased sales from lot users		Administrative and maintenance costs	Air, noise pollution around parking facility and additional traffic congestion if lots is large with substantial transit service

TABLE 7.4 (Continued)

Strategy	Nonusers	Transit Services	Employers	Retail Merchants	Shoppers	Municipal Costs	Other Impacts
16. Elimination of Employer Parking Subsidies	Elimination of parking spaces or additional cost of paying for parking	Same as Strategy No. 4	Eliminate cost of providing parking; Use land for other company purposes			Increased property tax from higher assessed value of property if used more productively	
17. Employer Financial Incentives	Equality of incentives since some employees are unable to form pools	Same as Strategy No. 4	Cost of incentive and administration				
18. Auto Free or Restricted Areas	Restrict areas of travel	Same as Strategy No. 4		Revitalize area and increase retail sales	Increase attractiveness of shopping areas	Construction and maintenance costs	
19. Staggered or Flexible Work	Increased flexibility of working times	Spreading out of peak loads, better utilization of resources	Initial administration costs			Initial administration costs	Increased use of vehicle for shopping and other trips as a result of flexibility in work times

TABLE 7.5 IMPLEMENTATION TIME BY STRATEGY

Ridesharing Strategy	Implementation Time
Carpool Matching Programs	Community wide: 6-12 months Employer programs: less than 6 months
Vanpool Programs	Community wide: 1-2 years Employer programs: 6-12 months Third party: 1-2 years
On-street Parking Restrictions	Less than 6 months
Off-street Parking Restrictions	6-12 months
Residential Parking Control	6-12 months
Exclusive Bus/carpool Lane Arterial	Take-a-Lane: 6 months to 2 years Add-a-Lane: 1-5 years
Contra-Flow Bus/Carpool Lane	6 months to 2 years
Reversible Lane Systems	6 months to 2 years
Freeway Bus/Carpool Bypass	6-12 months
Exclusive Bus/Carpool Lane Freeway	Take-a-Lane: 1-5 years Add-a-Lane: 2 to greater than 5 years
Special Bus/Carpool Turning Privileges	Less than 6 months
Vehicle Tolls	6-12 months
Carpool/Vanpool Preferential Parking	Less than 6 months
Parking Rate Changes	6-12 months
Park and Ride Facilities	6 months to 2 years
Elimination of Employer Parking Subsidies	6-12 months
Employer Financial Incentives	6-12 months
Auto Free or Restricted Areas	1-5 years
Staggered or Flexible Work Hours	Less than 6 months

parking strategies which are politically sensitive and require regulatory reforms. In general if strategies are politically sensitive or confronted with institutional issues, a longer implementation period for planning is usually necessary.

Ridesharing strategies in general require little time after implementation for action to be taken by commuters. Two or three months is all that is usually needed for commuters to respond to an action. Some strategies such as parking bans or restrictions have instantaneous results in providing a deterrant to driving alone but may take several weeks before changes in modes are realized. Matching programs on the other hand may require several months before mode changes occur as commuters wait for match lists to be returned and attempt to formalize ridesharing pools.

Identifying implementation and adjustment time periods enables the programming and selection of strategies which can be expected to produce increases in ridesharing early in the program. Selecting strategies that increase ridesharing demand early tends to stimulate community interests in ridesharing and maintains a commitment toward ridesharing by decision makers. If program results are long in coming as a result of selecting time consuming strategies, decision makers may become impatient with the program and make continued implementation difficult.

Program costs. Implementation costs for ridesharing strategies include the cost of planning, design, and construction. Costs can also be broken into two categories of direct and indirect program costs. Direct costs are those of capital outlays such as planning, design,

administration and annual program costs while indirect costs are user/nonuser costs and the cost to participating employers for administration and incentives. From the standpoint of formulating a program budget on a municipal level, direct costs are of primary interest since indirect costs are not usually financed with municipal monies. Even though indirect costs are not borne by local governments their consideration is important since program participation by employers and users is dependent upon the cost incurred by them and is also included in final economic analyses. Program costs can vary considerably for certain strategies depending upon their scope and intensity. For example, park and ride facilities can vary from joint use lots where construction costs are merely signing and striping to construction of expensive new parking lots. The same variation is true of carpool matching programs where community wide computerized programs are far more expensive than simple manual match boards at large individual employers. Table 7.6 lists associated costs for each type of strategy from past applications in 1979 dollars. Costs are reported in a range of values with the higher value usually representing more intense applications. Associating a project cost for each strategy is utilized in final economic analysis of candidate projects and enables modifications to be made to reduce costs within project limits.

Estimating demand. Determining the expected increases for ridesharing modes is an important yet difficult value to estimate. Estimating mode split changes is a key factor in strategy selection since determining the most effective strategies is critical for a successful

TABLE 7.6 RIDESHARING PROGRAM COSTS

Ridesharing Strategy	Program Costs
Carpool Matching Programs	Community Wide: $100,000 to $150,000 annually for medium sized city; $50,000 - $100,000 small urban area. Employer Sponsored: $5,000 - $45,000 start up costs; Moderately well-organized, promotion/matching program $12,000 in staff and materials; $4,000 - $10,000 annual administrative costs.
Vanpool Programs	Community wide: $60,000 initial startup; $40,000 - 60,000 annual fixed costs plus $500/van/year operational; initial cost of vans not included in startup costs. Employer sponsored: $18,000 - $35,000 startup and organizational cost plus cost of vans; $25,000 average; $250-350/van/year administrative cost. Third party: $65,000 - $130,000 startup plus cost of vans; $70,000 - 90,000 annual fixed costs plus $60-$80/van/year administrative costs
Onstreet Parking Restrictions	Initial planning and signing costs $50 - $75/sign Minimal annual maintenance costs (sign replacement)
Offstreet Parking Restrictions	Initial planning costs vary considerably with intensity of program, from 1 - 2 months to 1 - 2 years; Minimal annual costs
Residential Parking Control	$8,000 - $15,000 initial cost for planning, signing, issuing permits $6,000 - $12,000 annual cost for sign replacement & issuing new permits.
Exclusive Bus/Carpool Lane Arterial	Take-a-Lane: $20,000 - $50,000/mile signing, striping, minor construction Add-a-Lane: $160,000 - $250,000/mile (does not includ ROW) $12,600 - $38,000/mile annual operation & maintenance
Contra-Flow Bus/Carpool Lane	Take-a-Lane: $20,000 - $50,000/mile signing, striping, minor construction Add-a-Lane: $160,000 - $250,000/mile (does not include ROW) $12,600 - $38,000/mile annual operation & maintenance
Reversible Lane Systems	$5,000 - $10,000/mile signing & striping
Freeway Bus/Carpool Bypass	$4,000 - $8,000 per ramp for signing & striping $10,000 - $80,000 per ramp for widening/signalization
Exclusive Bus/Carpool Lane Freeway	Take-a-Lane: $10,000 - $30,000/mile signing, striping Add-a-Lane: $2.5 - 3.5 million/mile (does not include ROW) $10,000 - $30,000/mile operation & maintenance
Special Bus/Carpool Turning Privilege	Minimal signing/signal installation, & striping costs, $1,000 - $5,000 per application
Vehicle Tolls	Minimal administrative and promotional cost $5,000 - $10,000
Carpool/Vanpool Preferential Parking	Employer Program: Minimal signing and administrative costs, usually included in planning & administrative cost of carpool/vanpool program. Municipal program: $8,000 - $10,000 startup promotion, application processing, signing, and other materials; $1,000 - $5,000 annual cost.
Parking Rate Changes	$8,000 - $12,000 initial administrative cost. Minimal annual costs.
Park and Ride Facilities	$380 - $1,200/space, Avg $550/space initial construction cost $15 - $23/space annual maintenance
Elimination of Employer Parking	$3,000 - $6,000 initial employer administrative cost.
Employer Financial Incentives	Initial startup and annual administrative cost are included in cost associated with carpool/vanpool programs. Additional cost of incentives should be added to these costs.
Auto Free or Restricted Areas	$75,000 - $4,000,000 initial construction costs $10,000 - $50,000 annual maintenance costs
Staggered or Flexible Work Hours	$4,000 - $12,000 initial setup and administrative cost. No annual costs.

program. Existing techniques fall into two groups, those which estimate potential ridesharing demand through sophisticated mode split models or quick response manual methods, and market identification methodologies that identify commuter segments which have a high potential for ridesharing based on travel cost, time and distance characteristics, but provide no estimate of expected participation levels from these commuters.

From Chapter VI three techniques were suggested for determining demand; the DOE manual method, local administered surveys, and results from applications in other communities. In cases where sufficient time and financial resources are available a locally administered survey is recommended for estimating expected proportions. If candidate strategies are politically sensitive such as parking taxes or bans and it is anticipated that they would create public concern and pressures if presented in a survey, it is suggested that demand estimates be made through use of the DOE manual method rather than a local survey. A local survey should provide the most efficient and reliable estimates of expected participation levels since values are determined from local commuter responses rather than sophisticated modeling techniques or changes that occurred from applications in other areas.

A one page survey can be designed, administered and coded in a minimum of five weeks but often requires additional time as a result of unforeseen delays. Total costs for administering such a survey is primarily dependent upon the method of administration. In most instances either a self administered mailback or telephone survey are the most time and cost efficient methods. Home interviews while being more accurate, are costly and usually not within financial resources of

most planning organizations. Costs for a one page self administered survey range between $1.50 and $2.00 per completed survey while a telephone survey varies between $4 and $6 per completed survey. These costs include survey design, administration, and coding. Determining the exact sample size is dependent upon the population of the study area, projected population proportions using the incentive, sampling technique, and the level of confidence of expected results. Since the projected population proportion that may act favorably toward ride-sharing is usually below 50 percent, a high level of confidence should be maintained to ensure usable estimates. A minimum confidence level of 90 percent should be specified and preferably a 95 percent level. Since the method of calculating sample sizes is dependent upon the sampling technique, planners should consult an appropriate statistical sampling reference for exact procedures. As a conservative estimate using simple random sampling, a sample size of 270 would be required if a bound on the estimated proportion were 5 percent and a level of confidence of 90 percent (Cochran, 1963).

In situations where resources are not available for local surveys or candidate strategies are politically sensitive, demand can be estimated through use of the DOE manual method or utilizing measured changes from applications in other communities. Application of these two techniques while not providing as precise estimates as local surveys, should provide adequate participation estimates for strategy selection. As discussed in Chapter VI and Appendix E the DOE method requires reductions in mode shift values since application in Knoxville, Tennessee, resulted in values larger than those observed when financial incentives and matching programs were introduced. In

making adjustments, target market segments should be examined since application of strategies to large individual employers tends to have greater success than community wide programs. Appendix E presents the procedure and worksheets for estimating demand using the DOE manual method as well as example applications in Knoxville, Tennessee.

To aid planners in assessing and adjusting calculated values from the DOE method, Table 7.7 lists observed results from application of various strategies in other areas. The results are listed for both community wide and individual employer applications and include a range of values for each group where applications have been made. In general, the higher range of mode shift values correspond to situations where factors other than the implemented strategy contributed in stimulating ridesharing. In many cases strong employer commitment, congestion, or lack of parking were contributing factors to the strategy's success. For example, in the case of the TVA ridesharing program, employer commitment and reduced availability of parking were key elements besides financial incentives and commuter matching for the program's great success. Another important issue in utilizing the observed values is that most strategy applications were the first of their kind to the applied market and tended to attract those most willing to rideshare. If ridesharing levels are already high, application of strategies such as matching programs may produce little change since those who drive alone are strongly committed to do so. This was the experience when carpool matching and vanpooling was introduced at Union Carbide's facilities in Oak Ridge, Tennessee. Ridesharing was already high at approximately 50 percent as a result of a long commute distance (20 plus miles oneway) and those drive alone commuters were

TABLE 7.7 OBSERVED RIDESHARING DEMAND BY STRATEGY

Ridesharing Strategy	Observed Ridesharing Demand
1. Carpool Matching Programs	Community wide: 1 - 2.5% increase in area wide carpool share Employer program: 4-10% increase in carpooling
2. Vanpool Programs	Community wide: 1 - 2% increase in area wide vanpool share Employer program: 5 - 22% increase, average 8% increase
3. On-Street Parking Restrictions	No reported results except those for onstreet carpool spaces, see Strategy No. 13.
4. Off-Street Parking Restrictions	No reported ridesharing results. Increase in transit ridership as result of restriction in growth of parking supply.
5. Residential Parking Control	No reported ridesharing results. Eliminated onstreet parking by commuters substantially. Increased utilization of offstreet parking facilities were available.
6. Exclusive Bus/Carpool Lane Arterial	16% increase in vehicle occupancy
7. Contra-flow Bus/Carpool Lane	9% increase in vehicle occupancy
8. Reversible Lane Systems	100% increase in carpool usage (3 or more occupants per vehicle)
9. Freeway Bus/Carpool-Bypass	5 - 50% increase in new carpools, 30% average (higher values associated with 2 person carpools)
10. Exclusive Bus/Carpool Lane Freeway	4.0 - 14.7% increase in vehicle occupancy, 6.0% avg.
11. Special Bus/Carpool Turning Privileges	No reported results
12. Vehicle Tolls	58% increase in number of carpools (18% per year)
13. Carpool/Vanpool Preferential Parking	22-30% increase in new carpools at municipal lots & onstreet parking 17-29% increase in new carpools at individual employers
14. Parking Rate Changes	6% increase in vehicle occupancy as result of increased parking rates.
15. Park and Ride Facilities	45% increase in number of carpools at remote freeway lots
16. Elimination of Employer Parking Subsidies	8-10% reduction in drive alone commuters
17. Employer Financial Incentives	4-10% increase in carpooling 5-20% increase in vanpooling
18. Auto Free or Restricted Areas	No reported ridesharing results
19. Staggered or Flexible Work Hours	No reported ridesharing results

strongly committed to maintaining their current status. Thus, the level of expected demand for ridesharing is dependent upon the characteristics of the area, the type of strategy and its level of intensity.

Strategy Selection

In the preliminary and detailed evaluation phases, numerous evaluation and impact measures were assessed against each strategy. Through this analysis, costs, impacts and specific values were associated with these measures and now become the primary means for comparing and selecting strategies. To enable effective final selection, the overall evaluation process should provide sufficient summary information. Techniques that are suggested for use include economic efficiency analysis (benefit cost ratio, present worth, rate of return) and scoring methods. Since these methods are well documented in numerous texts, planners should consult an appropriate reference when applying these techniques (Cohen, 1978; DeGarmo, 1979). Through determining these summary measures, the most effective group of strategies can be selected and programmed for implementation. As a result of the evaluation process, a definite set of quantitative and qualitative values will be available for inclusion in the final selection decision. These values tend to place a specific value on the costs and benefits associated with each strategy and reduce the subjective nature of the decision process.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

Conclusions

The following four conclusions were reached concerning planning guidelines for selecting ridesharing strategies:

1. In developing a ridesharing program many alternative ridesharing strategies can be identified for application to a study area which possess varying degrees of acceptance based on community characteristics and commuting patterns. Each strategy or group of strategies will result in different types and degrees of impacts as well as effectiveness in encouraging new ridesharing arrangements. To ensure selection of the most effective strategies, a systematic analysis of alternatives should be undertaken. In selecting strategies a thorough analysis of the study area should be performed so strategies are applied to market segments most suited for their successful implementation. To enable this type of analysis a well defined set of planning guidelines should be followed such that essential factors are not overlooked when evaluating and selecting alternative ridesharing strategies. It is recommended that the guidelines developed in Chapter II be utilized when selecting a ridesharing program.
2. In an effort to determine simplified and inexpensive demand estimates of ridesharing mode split it was determined that

multiple linear regression equations utilizing characteristics of the trip and trip maker do not adequately distinguish between those commuters who rideshare and drive alone. Other mode split models that utilize different mathematical formulations and incorporate the carpool mode while distinguishing between modes better than regression analysis, are usually time consuming and costly to apply due to data requirements and model calibrations. To determine simplified and inexpensive demand estimates the following three techniques are recommended: (1) application of locally administered surveys to target market segments; (2) utilization of the DOE manual mode split model; and (3)examination of previous strategy applications in other areas.

3. In undertaking a ridesharing program a common objective is to reduce community or site specific vehicle miles of travel and energy usage by some specified amount. To assess whether ridesharing is realistically capable of achieving these desired reduction levels an analysis should be undertaken to determine the number of commuters that must participate in new or expanded ridesharing arrangements. In many cases a large reduction level may not be realistically obtainable if required participation levels exceed or approach the number of workers in the study area. It is recommended that required participation levels be determined early in the planning process through the supply models developed in this research or other appropriate techniques.

4. The attitudes and characteristics of ridesharers have been shown to be important factors in identifying market segments and candidate ridesharing strategies as well as gaining a better understanding and feel for ridesharing. Attitudes of nonridesharers as expressed through their reasons for not ridesharing can be used in identifying strategies that address these issues and influence a change in their behavior. In identifying market segments and selecting appropriate ridesharing strategies, it is recommended that commuter attitudes be considered in the analysis so that strategies address those issues which are most influential in an individuals decision to rideshare.

Recommendations for Further Research

The following four recommendations are suggested for further research.

1. To estimate potential demand for ridesharing as a result of alternative strategies there is a continued need for simplified, inexpensive sketch planning mode split models. In an effort to provide planners with a quick and inexpensive methodology, continued research should be directed toward developing quick response demand models that are more sensitive to the size of the study area and the level of intensity of proposed programs. Through continued research encompassing a variety of city sizes and program intensities, a quick response mode split model may be developed with a greater sensitivity to different environments.

2. In developing and selecting ridesharing strategies a better understanding of the reasons why some commuters rideshare and others drive alone is essential in providing a stimulus for encouraging the expansion or formation of new ridesharing arrangements. Continued research is needed concerning the attitudes of commuters toward ridesharing and driving alone. Determining attitudinal differences between groups of commuters based upon travel distance or population subgroups (male, female; young, old; white collar, blue collar) may identify strategies which will influence behavior and cause more individuals to rideshare. Different subgroups or market segments may have varying attitudes toward ridesharing and determining these differences may identify new or revised strategies which are more influential in encouraging ridesharing.

3. As new ridesharing strategies are introduced and changes in the commuting environment occur, the factors and considerations which are used to evaluate and develop a ridesharing program are also subject to change. The introduction of new strategies and changing environment may lead to additional factors being critical to a strategies successful implementation or additional considerations may become influential in current evaluation factors. As ridesharing programs grow and strategies become more widespread, evaluation factors may

also change to reflect this greater diversity in applications. As a result of these anticipated changes, the ridesharing planning guidelines, especially the evaluation factors, should be periodically updated.

4. An important element of identifying market segments and evaluating ridesharing strategies is the familiarity with the strategy and the type of application undertaken. By examining information on past applications in similar or other areas, planners are able to identify market segments which possess the greatest potential for successful implementation of a particular strategy and avoid the situation of applying strategies to markets that have previously shown to be incompatable. As a result, there should be a continued dissemination of empirical results from application of ridesharing strategies so that planners are continually provided with up-to-date information. Program information should be continually reported through professional organizations, ridesharing specialty conferences, newsletters, bibliographies of reported results, and the National Ridesharing Hotline operated by the U.S. Department of Transportation.

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APPENDIXES

APPENDIX A

BIBLIOGRAPHY INDEX OF RIDESHARING STRATEGIES

APPENDIX A

BIBLIOGRAPHY INDEX OF RIDESHARING STRATEGIES

A subject index for the references contained in the preceding List of References is contained in Table A.1. The index is divided into the eight major categories of ridesharing strategies. It is important to note that a particular reference number may appear under more than one subject classification if the reference contains information on multiple strategies.

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APPENDIX B

SURVEY INSTRUMENTS

SURVEY 1

TELEPHONE RIDESHARING FOLLOW-UP SURVEY

Population Surveyed

A sample of 1,575 names was systematically selected from CBD workers listed in the master file of the Knoxville Commuter Pool matching data base. Names were placed into the master file between January 1977 and March 1978.

Sample Size

Two hundred fourty-five (245) surveys were completed by both ridesharers and nonridesharers.

Survey Administration

The survey was administered in May and June 1978. Interviews were conducted during week day evening hours and interviewers were instructed to ask for the respondent by name; up to three attempts were made to reach selected respondents.

Returns

A total of 240 completed usable surveys were received.

Revised May 9, 1978

SURVEY OF MATCH LIST RECIPIENTS (K)

Date: _____

Phone: _____

FILL IN ID #

ID# _____ (1-4)

Card # 1 (5)

FILL IN: Hello, this is _____. May I please speak to _____? I'm calling for the Knoxville Commuter Pool regarding the ridesharing information we sent you a couple of months ago. May I have a few minutes of your time to ask you some questions?

1. Did you receive a computerized form from us in the past few months regarding a list of people who might be able to rideshare with you and/or some bus information? Q1. _____ (6)

☐ Yes (1) ☐ No (2) → 1a. Did you receive any earlier list? Q1a. _____ (7)

☐ No (1) ☐ Yes (2) 1b. Did you make any use of that list? Q1b. _____ (8)

☐ No (1) ☐ Yes (2) Please explain: _____

1c. Was that the first form of this type that you have received from the Knoxville Commuter Pool? Q1c. _____ (9)

☐ Yes (1) ☐ No (2)

SKIP TO 6

1d. Did you make any use of any earlier form? Q1d. _____ (10)

☐ No (1) ☐ Yes (2) Please explain: _____

READ: "Now I'd like to ask you about the form you recently received."

2. Did the form contain information on bus routes in your area? Q2. _____ (11)

☐ No (2)

☐ Not Sure (3)

☐ Yes (1) 2a. Did you begin riding the bus as a result of receiving this information? Q2a. _____ (12)

☐ No (1) ☐ Yes (2)

2b. How did you usually get to work before you began riding the bus? Q2b. _____ (13-14)

☐ Drove alone (01)

☐ Different bus (02)

☐ Drove or rode only with household member (03)

☐ Carpool (04)

☐ Vanpool (05)

☐ Other (specify): _____

CONTINUE AT 3.

3. Did your computerized form contain a list of names?

☐ No (2) → SKIP TO (6)

☐ Yes (1)

a. How many names were on your list?

☐ 0 (1) ☐ 1-2 (2) ☐ 3-6 (3) ☐ 7-10 (4) ☐ 11-15 (5)

☐ 16-20 (6) ☐ 21 or more (7) ☐ Not Sure (9)

Q3. _____ (15)

Q3a. _____ (16)

4. Did you contact anyone on your list about forming or joining a carpool or vanpool?

☐ Yes (1)

a. How many? ____

☐ No (2)

b. Is there a reason you chose not to contact anyone?

- ☐ Contacted by others first (01)
- ☐ Have not acted yet (02)
- ☐ No intention to pool (03)
- ☐ Changed mind about pooling (04)
- ☐ Insufficient info on form (05)
- ☐ Inconvenient match (06)
- ☐ Need car for work (07)
- ☐ Already in pool (08)
- ☐ Moved (09)
- ☐ Changed jobs (10)
- ☐ Other (specify): _____

Q4. _____ (17)

Q4a. _____ (18-19)

Q4b. _____ (20-21)

5. Were you contacted by anyone about forming or joining a pool because your name appeared on their list?

☐ No (2)

☐ Yes (1)

a. By how many? _____

Q5. _____ (22)

Q5a. _____ (23-24)

(6) Were you contacted by anyone about forming or joining a pool because your name appeared on their list?

☐ Yes (1)

a. By how many? _____

☐ No (2) → SKIP TO (8)

Q6. _____ (25)

Q6a. _____ (26-27)

Page 2

CONTINUE AT 7

7. As a result of this contact, did you make a new pooling arrangement?

☐ No (2) → SKIP TO (S)

☐ Yes (1)

a. How did you usually get to work before making this pooling arrangement?

☐ Carpool (04)
☐ Vanpool (05)
☐ Drove or rode only with household members (02)
☐ Drove alone (01)
☐ Regular Bus (06)
☐ Walked (03)
☐ Express Bus (07)
☐ Did not make trip (09)
☐ Other (specify): _____

b. How many others, besides you, were in your old pool? ____

c. How many others, besides you were in your new pool? ____

d. How many members of your new pool joined as a result of Knoxville Commuter Pool activities? ____

e. Does everyone in your new pool work for your employer?

☐ Yes (1)
☐ No (2)

el. How many companies are represented? ____

f. Would you have begun your new pooling arrangement if you had not received your form, been contacted, or seen the Knoxville Commuter Pool's ads?

☐ Yes (1) ☐ No (2)

g. How many others, besides you, were in your pool? ____

h. Does everyone in your new pool work for your employer? ____

☐ Yes (1) ☐ No (2)

hl. How many companies are represented? ____

i. Did your new pool arrangement allow you to change your plans about buying or selling a household vehicle?

☐ No (2) ☐ Yes (1)

(ASK RESPONDENT TO EXPLAIN.) _____

_____

(8) How many days per week do you generally travel to work?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Not employed/do not travel to work (9) → SKIP TO 15

CONTINUE at 9

Q7. ____ (28)
Q7a. ____ (29-30)
Q7b. ____ (31-32)
Q7c. ____ (33-34)
Q7d. ____ (35-36)
Q7e. ____ (37)
Q7el. ____ (38-39)
Q7f. ____ (40)
Q7g. ____ (41-42)
Q7h. ____ (43)
Q7hl. ____ (44-45)
Q7i. ____ (46)
Q8. ____ (47)

9. Are you a licensed driver? ☐ Yes (1) ☐ No (2)

10. Is a household vehicle regularly available for you to drive or ride to work? ☐ Yes (1) ☐ No (2)

[illegible] → SKIP TO 12

11. Is the use of this vehicle necessary for your job? ☐ Yes (1) ☐ No (2)

12 How do you presently travel to work?

PROBE

INTERVIEWER: IF MORE THAN ONE MODE IS SPECIFIED, ASK HOW MANY DAYS PER WEEK EACH MODE IS USED. RECORD THE NUMBER OF DAYS FOR EACH AND FOLLOW THE INSTRUCTIONS FOR THE RESPONSE MARKED HIGHEST ON THIS PAGE. IF ONLY ONE IS SPECIFIED, RECORD THE NUMBER OF DAYS FROM QUESTION 8 ABOVE.

DAYS TO FROM

# ___ ___	Carpool	→ 12a. With how many others? ___	
# ___ ___	Vanpool	12b. Do you ☐ only ride (1) ☐ only drive (2) ☐ share driving (3)	CONTINUE AT 12c
# ___ ___	Regular Bus	→ 12c. Did you begin using [mode(s)] because of the Knoxville Commuter Pool's activities?	
# ___ ___	Express Bus	☐ No (1) ☐ Yes (2) Please explain. ___	
# ___ ___	Drive alone		
# ___ ___	Ride or drive only with household member(s)		
# ___ ___	Other (specify): ___		

CONTINUE AT 13.

13. Approximately how many miles do you currently travel to work, one way? ___ ☐ Don't Know (-09)

14. Approximately how many minutes does this trip take, one way? ___

☐ Don't Know (-09)

15. What features do you personally like most about carpooling or vanpooling?

PROBE FOR UP TO THREE (3) ANSWERS.

- ☐ Cost savings (01)
- ☐ Relief from driving (02)
- ☐ Makes car available to others (03)
- ☐ Delays buying another car (04)
- ☐ Solves parking problems (05)
- ☐ Companionship (06)
- ☐ Time savings (07)
- ☐ Energy Conservation (08)
- ☐ Other (specify): ___
- ☐ None (99)

PAGE # 4

CONTINUE AT 16.

Q9. ___ (48)

Q10. ___ (49)

Q11. ___ (50)

Q12.
CP ___ ___ (51) (52)
VP ___ ___ (53) (54)
RB ___ ___ (55) (56)
EB ___ ___ (57) (58)
DA ___ ___ (59) (60)
DW ___ ___ (61) (62)
OT ___ ___ (63) (64)
OT ___ ___ (65) (66)
OT ___ ___ (67) (68)

Q12a. ___ (69-70)

Q12b. ___ (71)

Q12c. ___ (72)

Q13. ___ (73-75)

Q14. ___ (76-78)

ID# ___ (1-4)

Card # 2 (5)

Q15.
1) ___ (6-7)
2) ___ (8-9)
3) ___ (10-11)

16. What features do you personally dislike about carpooling or vanpooling?

PROBE FOR UP TO THREE (3) ANSWERS

- ☐ Schedule inconvenience (01)
- ☐ Distance inconvenience (02)
- ☐ Increased travel time (03)
- ☐ Reduced privacy (04)
- ☐ Increased expense (05)
- ☐ Reduced independence and mobility (06)
- ☐ Cannot use vehicle during day (07)
- ☐ Reduced comfort (08)
- ☐ Harder to work overtime (09)
- ☐ Personality conflicts (10)
- ☐ Other (specify): _____
- ☐ None (99)

Q16. 1) _____ (12-13) 2) _____ (14-15) 3) _____ (16-17)

17. Do you feel the Knoxville Commuter Pool is worth continuing?

☐ Yes (1) ☐ For others only (2) ☐ No (3) ☐ Not Sure (4)

Q17. _____ (18)

18. Would you be willing to pay a small fee for the kind of ridesharing information that the Knoxville Commuter Pool provides, for example, a list of people with whom you might carpool?

PROBE FOR SIZE OF FEE. ☐ Yes (1) ☐ No (2)

Comments: _____

Q18. _____ (19)

Q18a. _____ (20-23)

19. What kind of work do you do? GET JOB TITLE

_____

Q19. _____ (24-25)

Coding Categories:

01 Professional, technical and kindred workers	06 Operatives, except transport
02 Managers and administrators, except farm	07 Transport equipment operators
03 Sales workers	08 Laborers, except farm
04 Clerical and kindred workers	09 Farmers and farm managers
05 Craftsmen, foremen and kindred workers	10 Farm laborers and farm foremen
	11 Service workers, except private household
	12 Private household workers

20. To which of the following age groups do you belong? ☐ Under 20 (1); ☐ 20 to 44 (2); ☐ 45 to 64 (3); ☐ 65 or over (4); ☐ No answer (9)

Q20. _____ (26)

21. How many vehicles are there in your household? _____

Q21. _____ (27)

22. What is the last grade or year of school you completed? PROBE

- ☐ No formal schooling (1)
- ☐ Grade school (2)
- ☐ Some high school (3)
- ☐ High school diploma (4)
- ☐ Technical training (5)
- ☐ Some college (6)
- ☐ College degree or higher (7)
- ☐ Refused to answer (9)

Q22. _____ (28)

23. INTERVIEWER: MARK RESPONDENT'S SEX. IF NOT CERTAIN, ASK:

Are you ☐ male (1) or ☐ female (2) ?

Q23. _____ (29)

CONTINUE AT 24

SURVEY 2

TELEPHONE RIDESHARE FOLLOW-UP SURVEY

Population Surveyed

A 25 percent sample of 1,500 names was systematically drawn from the entire file of individuals listed in the Knoxville Commuter Pool matching data base. Names were placed in the master file between June 1976 and December 1976.

Sample Size

Four hundred seventy-six surveys were completed by both ridesharers and nonridesharers.

Survey Administration

The survey was administered in February and March, 1977. Interviews were conducted during weekday evening hours and the interviewers were instructed to ask for the individuals by name; when a busy signal, no answer, or a disconnected phone was encountered, no additional attempt was made to reach that individual.

Returns

A total of 466 completed usable forms were received.

KNOXVILLE COMMUTER POOL TELEPHONE FOLLOWUP SURVEY

Hello. This is (interviewer's name) of the Knoxville Commuter Pool. May I please speak to _____.
Some time ago we provided you with a list of potential carpoolers and now we would like to ask you some questions about it.

A1. Did you receive the computerized list of people who might be able to carpool with you?

____Yes

____No We're sorry, perhaps it was lost in delivery. If you are interested we'll be happy to send you a copy.

____No ____Yes

IF MATCH LIST WAS NOT RECEIVED SKIP TO B1

A2. How many names were on your list? ____None ____1-2
____Not sure X 3-6 ____7 or more

A3. Did you contact anyone on the list about forming or joining a carpool?

____No X Yes

A4. Is there a reason why you chose not to contact anyone?

X Inconvenient match
____Needed car at work
____Already in carpool
____I moved
____I changed jobs
____Have not acted yet
____No intention to carpool
____Insufficient info on form
____Changed mind about pooling
_____Other

A4. Did anyone contact you because your name appeared on a list?

____No ____Yes

IF "NO" ON BOTH A3 AND A4 SKIP TO A7

A5. As a result of this contact was ridesharing arranged with someone on the match list?

X No Why didn't it work out?
____Schedule differences
____Destination differences
____No one willing to drive
X We lived too far apart
_____Other

Yes ____ How many of those on the match list did you arrange to ride with?
_____(number)

IF "NO" SKIP TO A7

A6. Were you (both/all) employed by the same company?

____No How many different companies were involved?
_____(number)

X Yes

A7. How did you get to work before receiving the match list?

____Carpool
____Vanpool
With how many others ____?
_____Other

Drove alone____
Regular bus____
Express bus____

SKIP TO B1

A8. Would you have begun car/vanpooling if you had not received the match list or been exposed to the Knoxville Commuter Pool Advertisements?

____No X Yes

GO TO B1

B1. How do you get to work now?

____Drive alone
____Regular bus
____Express bus
_____Other

X Carpool
____Vanpool
With how many others? ____

CURRENT RIDESHARERS

IF A5 NOT MARKED "Yes," THEN NEVER RIDESHARER: SKIP TO D1

IF MARKED "Yes," THEN FORMER RIDESHARER

B2. How long did you rideshare before stopping?
____Days
____Weeks (circle one)
____Months

B3. Why didn't it work out?

____Schedule differences
____Personality conflict
____Too expensive
____Uncomfortable ride
____Lack of privacy
____Need car at work
____Couldn't work overtime
____Distances were inconvenient
_____Other

SKIP TO D1

B4. How long have you been ridesharing?
2 Years ____Months

B5. In your car/van pool do you only drive, only ride, or do you share driving?

X Only drive
____Only ride
____Share driving
With how many others?
_____(number)

CARPOOLERS SKIP TO D1

B6. Are you the operator or manager of a vanpool?

____No ____Yes

IF "No" SKIP TO D1

CONTINUE WITH C1

VANPOOL OPERATORS-MANAGERS

C1. Do you own your van, lease it, or what? ____Own van. Did you buy it to form a vanpool? ____Lease van. From whom do you lease it?

Other _____ ____No ____Yes ____KCP ____Dealer

C2. How many miles do you put on your van in an average month? _____Miles. How many of these miles are for commuting to work, and how many for personal use?

_____Commuting miles _____Personal miles

C3. How often does your van need your personal attention or maintenance? ____Daily ____2-3 times/week ____Weekly ____Less often

C4. How often does the van need professional service? ____ Monthly ____2-3 months ____More than 6 months

C5. Have you had any accidents while operating your van for commuting purposes? _____(number) Over how long a period of time?

_____months/years

C6. What was the major reason that you became a van operator? ____Make a profit ____Share expenses ____Personal use of van

Others_____

EVERYONE ANSWERS

D1. How many miles to you currently travel to work one-way? 15 Miles

D2. How many vehicles are there in your household? 2 Vehicles

D3. Is a household vehicle regularly available for you to ride or drive to work? ___No X Yes

D4. Are you a licensed driver? ___No X Yes

D5. What features do you like most about car or vanpooling? PROBE

X Cost savings
____Time savings
____Relief from driving
____Companionship
____Dependability
____Eliminates buying another car
____Solves parking problems
____Conserves energy and resources
____Leaves my vehicle available for someone else
Other_____

D6. What features do you like least about car or vanpooling? PROBE

X Schedule inconvenience
____Distance inconvenience
____Increased travel time
____Reduced privacy
____Increased expense
X Reduced independence and mobility
____Can't use vehicle during day
____Reduced comfort
____Harder to work overtime
____Disagreements with other members
Other_____

D7. Do you feel that the Knoxville Commuter Pool Project is worth continuing? ___No X Yes

D8. To which age group do you belong? Are you ___under 20; ___20-44; X 45-64; ___or 65 and over?

D9. What is the last grade or year of regular school you attended?

____no formal schooling
____grade school
____some high school
X high school degree
____technical training
____some college
____college degree or higher

D10. INTERVIEWER: MARK RESPONDENT'S SEX. IF NOT CERTAIN, ASK: "Are you ___male or ___female?"

D11. Are you employed? ___No Are you a ____Student? X House spouse? X Yes Describe briefly the kind of work you do
____Retired _____Other

D12. Which of the following categories includes the combined annual income of all members of your household? Is it...

_____less than $5,000
_____$5,000-$9,999
_____$10,000-$14,999
_____$15,000-24,999
_____$25,000 and over

D13. The following information is currently in our ridesharing file. Please let me know if any corrections should be made.

Name
Home address
Work hours
Work Location
Phone
Ride/drive preference

SURVEY 3

SELF-ADMINISTERED MAILBACK DOWNTOWN EMPLOYEE SURVEY

Population Surveyed

A sample of all employees at four downtown employers, Miller's Department Store, South Central Telephone Company, United American Bank, and Valley Fidelity Bank. The survey was conducted as part of Knoxville's Downtown Leads the Way Transit Program.

Sample Size

One thousand (1,000) forms were distributed between the four employers.

Survey Administration

Survey forms were distributed to employees through plant coordinators who also collected completed forms. The survey was conducted in November 1977.

Returns

A total of 305 completed usable forms were received for a 30.5 percent response.

1977 DOWNTOWN KNOXVILLE TRANSPORTATION SURVEY

We're trying to give Downtown Knoxville the best possible transportation system, but we need your help. You have been chosen as one of a group of employees who are being surveyed this week in the first of a two-part effort to help us learn more about travel patterns and needs in the downtown. Please take a few minutes to help improve your transportation services.

Randy Tyree

RANDY TYREE, Mayor, City of Knoxville

For office use

_____ (1)
_____ (2)
_____ (3-6)

THIS INFORMATION IS CONFIDENTIAL AND WILL BE USED FOR TRAVEL STUDIES ONLY.

1. What is today's date? 11-3-77

_____ (7)

2. a. How did you travel to work yesterday?

- [x] drove alone
- [ ] regular bus
- [ ] express bus
- [ ] walked
- [ ] carpool
- [ ] vanpool

_____ (8) With how many others? ____

- [ ] other (specify) _____

b. How much did yesterday's trip cost you to make (round-trip)? (Please indicate your daily cost, if any, in each category. If you pooled, enter your share of any costs.)

_____ (9-12) $ 0.60 fares (transit or pool)

_____ (13-16) $ 0.00 parking

_____ (17-20) $ 1.00 automobile operating expense

_____ (21-24) $. other (specify) _____

_____ (25-27) c. Approximately how many miles do you travel to work (one-way)? 15

_____ (28-30) d. Approximately how long does this trip usually take (one-way)? 20 minutes

_____ (31-32) 3. How often do you tend to shop or dine out in the downtown (including lunches)? 5 (number of) times per week

_____ (33-35) 4. Approximately how much money do you typically spend in downtown stores and restaurants each week? $ 10

_____ (36) 5. How often do you typically ride a regular or express bus (for any purpose)?

- [ ] 4 or more days a week
- [ ] 2 or 3 days a week
- [ ] once every week or two
- [ ] very seldom
- [ ] practically never
- [x] never

For office use

_____(37-38)

6. After your trip to work, how many (one way) trips did you make yesterday, up to and including your travel home from work? → 2

Each destination defines a single trip; thus, if you left work to go eat lunch, went to the bank and returned to work, and at the end of the day you returned home, you would have made four trips.

For each of these trips, please provide the following information, listing the trips in order, starting with your first trip after arriving at work.

Origin and Destination: Please describe by address or location (for example, "TVA on Market Street, Knoxville").

Means of Travel: Please indicate "auto," "bus," "walk," or any other means you used.

Trip Purpose: Please select from the following categories, if possible, otherwise specify:

1. job related travel
2. lunch
3. shopping
4. personal business (e.g., banking)
5. return to work
6. return to home

_____(39-42)
_____(43-46)
_____(47)
_____(48)

Trip 1
From: Work To: Randy's
Means of Travel: car Purpose: Fun + games + free dinner

_____(49-52)
_____(53-56)
_____(57)
_____(58)

Trip 2
From: Randy's To: home
Means of Travel: car Purpose: sleep

_____(59-62)
_____(63-66)
_____(67)
_____(68)

Trip 3
From: _____ To: _____
Means of Travel: _____ Purpose: _____

_____(69-72)
_____(73-76)
_____(77)
_____(78)

Trip 4
From: _____ To: _____
Means of Travel: _____ Purpose: _____

_____(2-5)
_____(6-9)
_____(10)
_____(11)

Trip 5
From: _____ To: _____
Means of Travel: _____ Purpose: _____

_____(12-15)
_____(16-19)
_____(20)
_____(21)

Trip 6
From: _____ To: _____
Means of Travel: _____ Purpose: _____

For office use

_____ (22-25)

_____ (26-31)

7. What is the major street intersection nearest your home (for example, "Kingston Pike and Northshore Drive")?

Middlebrook Weisgarber

_____ (32)

8. Is a household vehicle regularly available for you to ride or drive to work?

☒ Yes ☐ No

_____ (33)

9. Are you a licensed driver?

☒ Yes ☐ No

_____ (34)

10. To what age group do you belong?

☒ under 20 ☐ 45-64
☐ 20-44 ☐ 65 and over

_____ (35)

11. What is the last grade or year of regular school you attended?

☐ no formal schooling ☐ technical training
☐ grade school ☒ some college
☐ some high school ☐ college degree(s)
☐ high school degree

_____ (36)

12. Are you ☐ male or ☒ female?

_____ (37)

13. How many vehicles are owned or operated by members of your household?

3

_____ (38)

14. How many members of your household are licensed to drive? 3

_____ (39)

15. Which category best describes the kind of work you do?

☒ clerical ☐ craftsman
☐ professional/technical ☐ equipment operator
☐ management/administration ☐ service worker
☐ sales ☐ other (specify)

_____ (40)

16. Which of the following categories includes the combined annual income of all members of your household?

☐ less than $5,000 ☐ $15,000 - $19,999
☐ $5,000 - $9,999 ☐ $20,000 - $24,999
☒ $10,000 - $14,999 ☐ $25,000 and up

Your cooperation in completing this survey is greatly appreciated. Next spring we would like to contact you again to complete this study. Please make this possible by writing your first name and home telephone number below.

First Name Kathy Telephone Number 693-5317 (home)

Thank you very much for your assistance.

THIS INFORMATION IS CONFIDENTIAL AND WILL BE USED FOR TRAVEL STUDIES ONLY.

Please seal and return to your personnel director in the enclosed envelope.

SURVEY 4

GENERAL POPULATION TELEPHONE TRANSPORTATION SURVEY

Population Surveyed

The survey population was restricted to commuters living within the service area of the Knoxville Commuter Pool. This included individuals living in Anderson, Blount, Knox and Union Counties and working in the Knoxville "core area".

Survey Administration

Respondents were selected by random digit dialing of nonbusiness telephone exchanges within the study area in proportion to populations within the exchanges. Calls were made on weekday evenings and during the day on weekends. The survey was conducted between May and June, 1978.

Returns

A total usable sample size of 476 forms were received.

· Revised May 7, 1978 GENERAL POPULATION Date: [redacted]

TRANSPORTATION SURVEY (G2) Phone No. [redacted]

FILL IN: Hello, this is [redacted]. I am conducting a survey about transportation and commuting patterns in your area. Could I have a few minutes of your time to ask you some questions?

FILL IN: ID# 5210 (1-4) Card # 1 (5)

1. Do you travel to work regularly?

If both "yes" and "no", code only "yes."

☒ Yes (1) ☐ No (2)

CONTINUE AT 2

ASK IF THERE IS A COMMUTER IN THE HOUSE WITH WHOM YOU MAY SPEAK; IF SO, RETURN TO QUESTION 1 ON THIS FORM. OTHERWISE, TERMINATE.

Q1. 1 (6)

2. In what county do you work?

If both core and non-core, code only core.

CORE
- ☐ Anderson (01)
- ☒ Blount (02)
- ☐ Knox (03)
- ☐ Union (04)
- ☐ Roane/employed at Union Carbide (05)

NON-CORE
- ☐ Campbell (06)
- ☐ Claiborne (07)
- ☐ Cocke (08)
- ☐ Grainger (09)
- ☐ Hamblen (10)
- ☐ Jefferson (11)
- ☐ Louden (12)
- ☐ Monroe (13)
- ☐ Morgan (14)
- ☐ Roane/not U.C. (15)
- ☐ Scott (16)
- ☐ Sevier (17)
- ☐ Other (18)

Q2. 02 (7-8)

CONTINUE AT 3

IF RESPONDENT WORKS IN (NON-CORE) COUNTIES 06 - 18, ASK IF THERE IS ANOTHER COMMUTER IN THE HOUSE WITH WHOM YOU MAY SPEAK. IF ONE IS AVAILABLE, RETURN TO QUESTION 1 ON THIS FORM. OTHERWISE, TERMINATE.

3. Have you heard or seen anything about the Knoxville Commuter Pool?

☒ Yes (1) ☐ No (2) IF "NO", SKIP TO 7

Q3. 1 (9)

4. How did you learn about the Commuter Pool? UP TO TWO (2) ANSWERS

- ☐ At place of employment (01)
- ☐ Friends in the community (02)
- ☐ Television (03)
- ☒ Newspaper (04)
- ☐ Posters/Billboards (05)
- ☐ Radio (06)
- ☐ Saw van (07)
- ☐ Other (specify) _____
- ☐ No answer/Don't know/None (99)

Q4. 1) 04 (10-11) 2) (12-13)

5. What forms of commuter pooling do you associate with the program?

- ☐ Car (01)
- ☐ Van (02)
- ☐ Express Bus (03)
- ☐ Other (specify) _____
- ☐ Car and Van (04)
- ☐ Car and Express Bus (05)
- ☐ Van and Express Bus (06)
- ☐ Car, Van and Express Bus (07)
- ☒ No answer/Don't know/None (99)

Q5. 07 (14-15)

6. Have you ever received a list of people who might be able to carpool or vanpool with you and/or personalized bus information from the Knoxville Commuter Pool?

☐ Yes (1) ☒ No (2) ☐ Received form containing no information (3)

Q6. 2 (16)

CONTINUE AT 7.

7 What kind of work do you do? [illegible]

GET JOB TITLE [illegible]

Coding Categories:

01 Professional, technical and kindred workers	06 Operatives, except transport
02 Managers and administrators, except farm	07 Transport equipment operators
03 Sales workers	08 Laborers, except farm
04 Clerical and kindred workers	09 Farmers and farm managers
05 Craftsmen, foremen and kindred workers	10 Farm laborers and farm foremen
	11 Service workers, except private household
	12 Private household workers

Q7. 05 (17-18)

8. Are you a licensed driver? ☒ Yes (1) ☐ No (2) Q8. 1 (19)

9. Is a household vehicle regularly available for you to drive or ride to work? ☒ Yes (1) ☐ No (2) Q9. 1 (20)

Code "NO (2)" in both Q9 and Q10.

SKIP TO 11

10. Is the use of your own vehicle necessary for your job? ☐ Yes (1) ☐ No (2) Q10. 1 (21)

11 Where are you employed?

Employer's Name: [illegible]

Employer's Location: (City) [illegible]

Q11. (22-23)

12. How many days per week do you generally travel to work?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☒ 6 ☐ 7 Q12. 6 (24)

13. Approximately how many miles do you travel to work, one way? 4

☐ Don't Know (-09) Q13. NA (25-27)

14. How do you presently travel to work?

INTERVIEWER: IF MORE THAN ONE MODE IS SPECIFIED, ASK HOW MANY DAYS PER WEEK EACH MODE IS USED. RECORD THE NUMBER OF DAYS (IN EACH DIRECTION) FOR EACH MODE. IF CARPOOL/VANPOOL IS USED, SKIP TO QUESTION 21. IF BUS IS USED (AND CARPOOL/VANPOOL IS NOT USED), SKIP TO QUESTION 26. OTHERWISE, CONTINUE AT QUESTION 15.

IF ONLY ONE MODE IS SPECIFIED, RECORD NUMBER OF DAYS (IN EACH DIRECTION) FROM QUESTION 12 (ABOVE) AND PROCEED AS INDICATED.

# DAYS TO	# DAYS FROM		Q14.
# 6	6	Drive Alone	DA 1 1 (28) (29)
# ___	___	Drive or ride only with household members	DW ___ ___ (30) (31)
# ___	___	Walk	W ___ ___ (32) (33)
# ___	___	Other (specify): ___	CP ___ ___ (34) (35)
# ___	___	Carpool	VP ___ ___ (36) (37)
# ___	___	Vanpool	RB ___ ___ (38) (39)
# ___	___	Regular Bus	EB ___ ___ (40) (41)
# ___	___	Express Bus	OT ___ ___ (42) (43)
			OT ___ ___ (44) (45)

CONTINUE AT 15

SKIP TO 21

SKIP TO 26

15. Approximately how many minutes does this trip take, one way? 7

☐ Don't Know (-09)

Q15. 07 (46-48)

16. What do you estimate is your daily commuting cost by the means you use most often for each of the following categories?

READ CATEGORIES

$ ____ automobile operating expenses

$ ____ parking

$ ____ other (specify) _____

Code Total in Cents

Q16. 00 (49-51)

☒ No idea/Don't know (-09)

17 Have you changed the means by which you travel to or from work since January, 1976?

☐ Yes (1) ☒ No (2)

Q17. 2 (52)

SKIP TO 32

18. By what other means did you travel during this period?

Multiple responses o.k. Record in order 1-2 etc.

☐ Drove alone (1)

☐ Drove or rode only with household members (2)

☐ Walked (3)

☐ Other (specify) _____

☐ Carpool (4)

☐ Vanpool (5)

☐ Regular Bus (6)

☐ Express Bus (7)

Q18. 0 (53) 0 (54)

SKIP TO 32

If any above go to Q19. If multiple, ask which is most recent. Show order.

19. How long had you used [Mode] before stopping?

Read answer to 18

____ years ____ months

Code in Months if over 99, code 99.

Q19. 01 (55-56)

20. Why did you stop traveling by [mode].

READ ANSWER TO 18 UP TO TWO (2) ANSWERS

☐ Changed trip or job (01)

☐ Schedule differences (02)

☐ Needed car at work (03)

☐ Interfered with overtime (04)

☐ Excessive travel time or distance (05)

☐ Personality conflict (06)

☐ Lack of comfort (07)

☐ Lack of privacy (08)

☐ Other (specify) _____

Q20. 1) 99 (57-58) 2) 00 (59-60)

SKIP TO 32

ASK FOR CURRENT CARPOOL AND VANPOOL MEMBERS ONLY

21. How many other people, besides you, are in your pool? _____ people — Q21. 00 (61-62)

22. Is everyone in your pool employed by the same company? — Q22. 2 (63)

☐ Yes (1) ☐ No (2)

22a. How many companies are represented? ____ — Q22a. 00 (64-65)

23. In your car/vanpool, do you? — Q23. 0 (66)

☐ only ride (1) ☐ share driving (3)

☐ only drive (2)

23a. With how many others do you share the driving? _____ — Q23a. 00 (67-68)

24. Approximately how many minutes does your car/vanpool trip take you, one way? _____ ☐ Don't Know (-09) — Q24. 20 (69-71)

25. What do you estimate is your average daily commuting cost for each of the following categories when you are are pooling?

READ CATEGORIES

$ ____.__ automobile operating expense

$ ____.__ parking

$ ____.__ fare

$ ____.__ other (specify): _____

Code Total in Cents → Q25. . (72-74)

☐ No idea/Don't Know/None (-09)

SKIP TO 28

ASK FOR CURRENT BUS RIDERS ONLY.

26. Approximately how many minutes does your bus trip take you, one way? ____ — Q26. (75-77)

☐ Don't Know (-09)

27. What is your daily commuting cost for riding the bus to and from work?

$ ____.__ fares and transfers

$ ____.__ other (specify): _____

Code Total in Cents → Q27. . (78-80)

☐ No Idea/Don't Know/None (-09)

CONTINUE AT 28.

ASK FOR ALL CURRENT RIDESHARERS (CARPOOL, VANPOOL, OR BUS).

28 How long ago did you start ridesharing?

____ years ____ months → Code in Months

Q28. 004 (6-8)

29. Has ridesharing allowed you to delay or cancel your plans to buy a vehicle?

☐ Yes (1) ☐ No (2) ☐ (3) Have to buy sooner

Q29. 2 (9)

30. Has ridesharing allowed you to sell a household vehicle?

☐ Yes (1)

☐ Did not previously have or use a vehicle (3)

☐ No (2)

Q30. 2 (10)

30a. What use is now being made of the vehicle you previously used for commuting?

Q30a. 1) 99 (11-12)

☐ I'm still driving it (01)

☐ vehicle remains unused at home (02)

☐ vehicle is used for part of commuting trip (03)

☐ other (specify) _____

Can be both

☐ vehicle is used part of the week for commuting (04)

☐ vehicle used by other household members (05)

2) 99 (13-14)

IF "used by other" IS SPECIFIED, ASK:

30b. Approximately how many miles per week is this vehicle used, during your working hours, by other household members?

____ miles

Q30b. 000 (15-17)

31. How did you get to work before your present means of ridesharing?

☐ drove alone (01)
☐ drove or rode only with household members (02)
☐ walked (03)
☐ other (specify) _____

☐ carpool (04)
☐ vanpool (05)
☐ regular bus (06)
☐ express bus (07)

☐ didn't make trip (99)

Q31. 99 (18-19)

CONTINUE AT 32

ID# _____ (1-4)

Card # 2 (5)

32. Has your means of traveling to or from work ever been influenced in any way by the activities of the Knoxville Commuter Pool?

☐ No (2) ☐ Yes (1)

32a. How? _____

Q32. 2 (20)

INTERVIEWER: PROBE RESPONDENT FOR ANSWERS TO 33 and 34.

33. What features do you personally like most about carpooling or vanpooling? UP TO 3 ANSWERS

- ☐ cost savings (01)
- ☐ relief from driving (02)
- ☐ makes my car available to others (03)
- ☐ delays buying another car (04)
- ☐ solves parking problems (05)
- ☐ companionship (06)
- ☐ time savings (07)
- ☐ energy conservation (08)
- ☐ none (99)
- ☐ other(s) (specify) _____

Q33. 1) 09 (21-22)
2) _____ (23-24)
3) _____ (25-26)

34. What features do you personally like least about carpooling or vanpooling? UP TO 3 ANSWERS

- ☐ schedule inconvenience (01)
- ☐ distance inconvenience (02)
- ☐ increased travel time (03)
- ☐ reduced privacy (04)
- ☐ increased expense (05)
- ☐ other(s) (specify) _____
- ☐ reduced independence and mobility (06)
- ☐ cannot use vehicle during the day (07)
- ☐ reduced comfort (08)
- ☐ harder to work overtime (09)
- ☐ personality conflicts (10)
- ☐ none (99)

Q34. 1) 00 (27-28)
2) _____ (29-30)
3) _____ (31-32)

35. Do you feel that the Knoxville Commuter Pool is worth continuing?

☐ Yes (1) ☐ For others only (2) ☒ No (3) ☐ Not sure (4)

Q35. 3 (33)

36. Would you be willing to pay a small fee for the kind of ridesharing information the Knoxville Commuter Pool provides, for example, a list of people with whom you might carpool?

Comments _____

☐ Yes (1) ☐ No (2)

PROBE FOR FEE SIZE: CODE IN CENTS →

Q36. 2 (34)

Q36a. 0100 (35-38)

CONTINUE AT 37.

37. In what county do you live?

☐ Anderson (01)	☐ Campbell (06)	☐ Louden (12)
☐ Blount (02)	☐ Claiborne (07)	☐ Monroe (13)
☒ Knox (03)	☐ Cocke (08)	☐ Morgan (14)
☐ Union (04)	☐ Grainger (09)	☐ Roane/not Oak Ridge (15)
	☐ Hamblen (10)	☐ Scott (16)
☐ Roane/Oak Ridge (05)	☐ Jefferson (11)	☐ Sevier (17)

Q37. 02 (39-40)

38. To which age group do you belong? Are you: ☐ Under 20 (1)
☐ 20-44 (2) ☒ 45-64 (3) ☐ 65 or over (4) ☐ No answer (9)

Q38. 3 (41)

39. What is the last grade or year of school you completed? PROBE

☐ No formal schooling (1)	☐ Technical training (5)
☐ Grade school (2)	☐ Some college (6)
☒ Some high school (3)	☐ College degree or higher (7)
☐ High school diploma (4)	☐ Refused to answer (9)

Q39. 5 (42)

INTERVIEWER: MARK RESPONDENT'S SEX. IF NOT CERTAIN, ASK.

40. Are you: ☒ Male (1) or ☐ Female (2) ?

Q40. 1 (43)

41. Which of the following categories includes the combined annual income of all members of your household?

☐ Less than $5,000 (1)	☒ $15,000 - $24,999 (4)
☐ $5,000 - $9,999 (2)	☐ $25,000 or over (5)
☐ $10,000 - $14,999 (3)	☐ Refused to answer (9)

Q41. 4 (44)

THANK YOU FOR YOUR ASSISTANCE!

Comments: _____

INTERVIEWER: DID YOU ENCOUNTER ANY PROBLEMS IN DETERMINING HOW TO INDICATE ANY OF THE RESPONSES?

☐ Yes (1) ☐ No (2)

Please explain. _____

I. 2 (45)

SURVEY 5

SELF-ADMINISTERED FOLLOW-UP SURVEY OF KCP MATCHING APPLICANTS

Population Surveyed

All individuals receiving a computerized match list from the Knoxville Commuter Pool between March 15, 1976 and February 30, 1977.

Sample Size

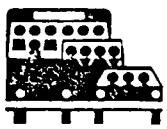
Approximately 14,000 forms were distributed.

Survey Administration

Survey forms were attached to the computer match list which requested that each individual complete the form and return it to the plant coordinator.

Returns

A total of 759 completed usable forms were received for a 5.4 percent response rate. Most forms were completed and returned within two weeks of receiving the computer match list.



Knoxville Commuter Pool

The results of the ridesharing survey that you recently completed are being returned. In order to improve the program we are interested in learning your response to the survey and your views about ridesharing. Your cooperation in completing this form is greatly appreciated.

PLEASE DO NOT MARK IN THIS COLUMN

1. HOW DID YOU FIRST LEARN ABOUT THE KNOXVILLE COMMUTER POOL? (Please check one)

- ☐ From your employer
- ☐ Friends in the community
- ☐ Friends at work
- ☐ Newspaper
- ☐ Posters/Billboards
- ☐ Radio
- ☐ Relatives or family
- ☐ Television
- ☐ Other _____ (Please Specify)

1 2

2. WAS THE SURVEY FORM EASY TO FILL OUT? (Circle one response for each question)

Very Difficult — Moderately Difficult — Moderately Easy — Very Easy

3

WERE THE INSTRUCTIONS EASY TO FOLLOW?

Very Difficult — Moderately Difficult — Moderately Easy — Very Easy

4

FURTHER COMMENTS ABOUT THE SURVEY FORM _____ (Please Specify)

3. IF YOU DECIDE TO SHARE A RIDE WITH YOUR FELLOW EMPLOYEES, WOULD YOU BE INTERESTED IN

	Very Interested	Moderately Interested	Not Interested
Carpooling			
Sharing the driving	☐	☐	☐
Driving only	☐	☐	☐
Riding only	☐	☐	☐
Vanpool	☐	☐	☐
Regular Bus	☐	☐	☐
Express Bus	☐	☐	☐

5 6 7

8 9 10

4. HOW DO YOU PLAN TO USE THE INFORMATION PROVIDED BY THE SURVEY? (Check those applicable)

- ☐ Will telephone the potential ridesharers at their home.
- ☐ Will contact potential ridesharers at work.
- ☐ Will postpone contacting other ridesharers and study the situation.
- ☐ Really not interested in contacting others at this time.
- ☐ Other _____ (Please Specify)

11 12 13 14

15

5. IF YOU COULD NOT FORM A RIDESHARING POOL OR DID NOT WANT TO, WHAT WERE YOUR REASONS FOR NOT RIDESHARING? (Check those applicable)

- ☐ Would rather drive alone
- ☐ Need vehicle at work
- ☐ Did not know the other riders in the pool well enough
- ☐ Did not like the personalities of other riders in the pool
- ☐ Other riders did not want to form pool
- ☐ Other _____ (Please Specify)
- ☐ Inconvenient
- ☐ Could not contact the other potential ridesharers
- ☐ Work overtime
- ☐ Having changing work hours or days
- ☐ You or other riders live too far away from each other
- ☐ Other riders work at different times

16 17 18 19

20 21 22 23

24 25 26 27

(OVER)

PLEASE DO NOT MARK IN THIS COLUMN

28 29 30 31
32 33 34 35
36 37 38
39 40 41
42
43
44 45 46
47
48
49 50 51 52
53 54 55 56
57 53 59 60
61 62 63 64

6. IF YOU ARE NOW SHARING A RIDE, OR PLAN TO DO SO IN THE FUTURE, WHAT MADE YOU DECIDE TO JOIN A CARPOOL, VANPOOL, OR BUSPOOL? (Check those applicable)

- ☐ Make your car available for someone else to use during the day
- ☐ Knew other members of the pool at work
- ☐ Knew other members of the pool in my neighborhood
- ☐ Do not own a car
- ☐ More dependable than regular bus service
- ☐ Other _____ (Please Specify)
- ☐ Conserve gasoline
- ☐ Avoid driving every day
- ☐ Avoid buying a second car
- ☐ Save money
- ☐ Availability and cost of parking

7. YOU ARE:

- ☐ Male
- ☐ Female
- ☐ Married
- ☐ Single

8. YOUR AGE: (Please check one)

- ☐ Under 21
- ☐ 21 - 30
- ☐ 31 - 40
- ☐ 41 - 50
- ☐ 51 - 60
- ☐ over 60

9. HOW MANY VEHICLES ARE AVAILABLE IN YOUR HOUSEHOLD FOR TRAVELING TO WORK? (Please check one)

- ☐ None
- ☐ 1 Vehicle
- ☐ 2 Vehicles
- ☐ 3 Vehicles
- ☐ 4 or more vehicles

10. WHAT LEVEL OF EDUCATION HAVE YOU COMPLETED? (Please check one)

- ☐ Less than 8 years
- ☐ Some high school
- ☐ High school graduate
- ☐ Some college or technical training
- ☐ College graduate
- ☐ Advanced graduate degree

11. WHAT IS YOUR JOB DESCRIPTION?

_____ (Job Title or Description)

12. BEFORE YOU FILLED OUT THE RIDESHARING QUESTIONNAIRE, HOW MUCH DID YOU UNDERSTAND ABOUT HOW THE KNOXVILLE COMMUTER POOL RIDESHARING PROGRAM COULD SAVE YOU MONEY AND CONVENIENCE IN TRAVELING TO WORK? (Circle one response)

Understood Nothing — Understood A Little — Understood Fairly Well — Understood Very Well

13. AFTER FILLING OUT THE RIDESHARING QUESTIONNAIRE AND READING THE INFORMATION ABOUT RIDESHARING, HOW MUCH DO YOU NOW UNDERSTAND ABOUT RIDESHARING AND HOW IT CAN SAVE YOU MONEY AND CONVENIENCE IN TRAVELING TO WORK? (Circle one response)

Understand Nothing — Understand A Little — Understand Fairly Well — Understand Very Well

Thank You

Please Return To:

Holiday Inn South

APPENDIX C

SUPPLY MODELS

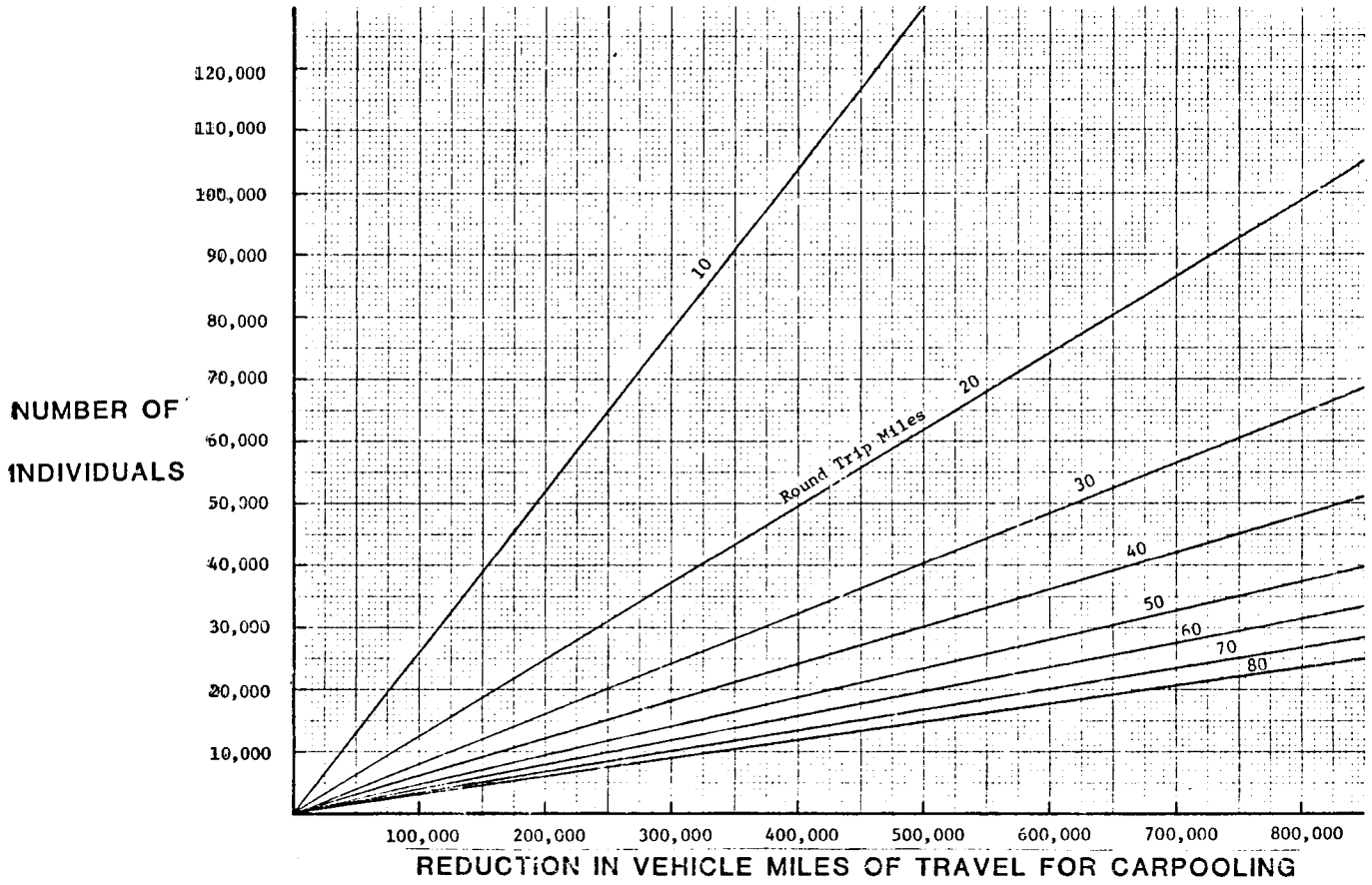


FIGURE C.1 NUMBER OF INDIVIDUALS NEEDED TO CARPOOL FOR REDUCTION IN VEHICLE MILES OF TRAVEL

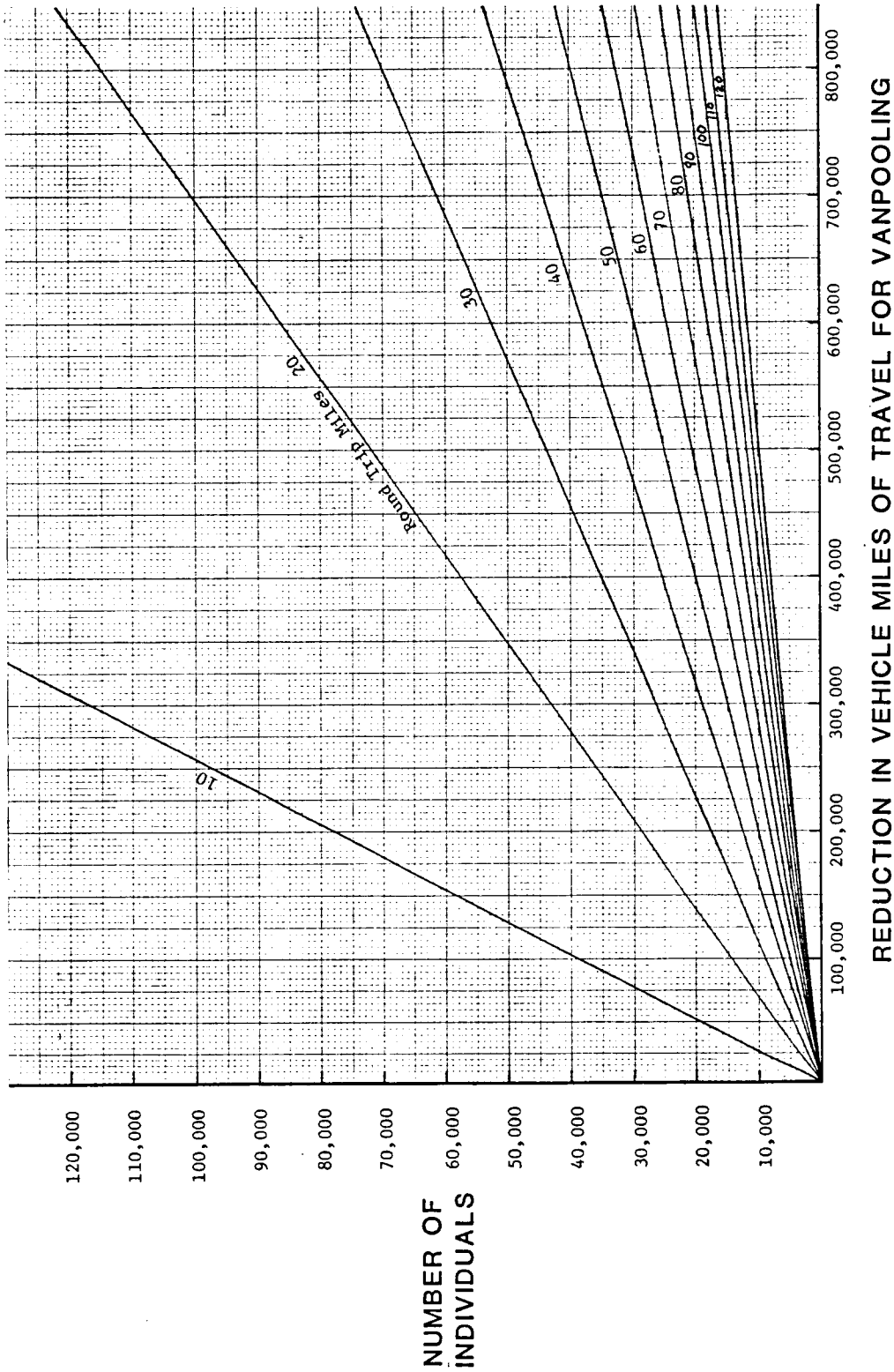


FIGURE C.2 NUMBER OF INDIVIDUALS NEEDED TO VANPOOL FOR REDUCTION IN VEHICLE MILES OF TRAVEL

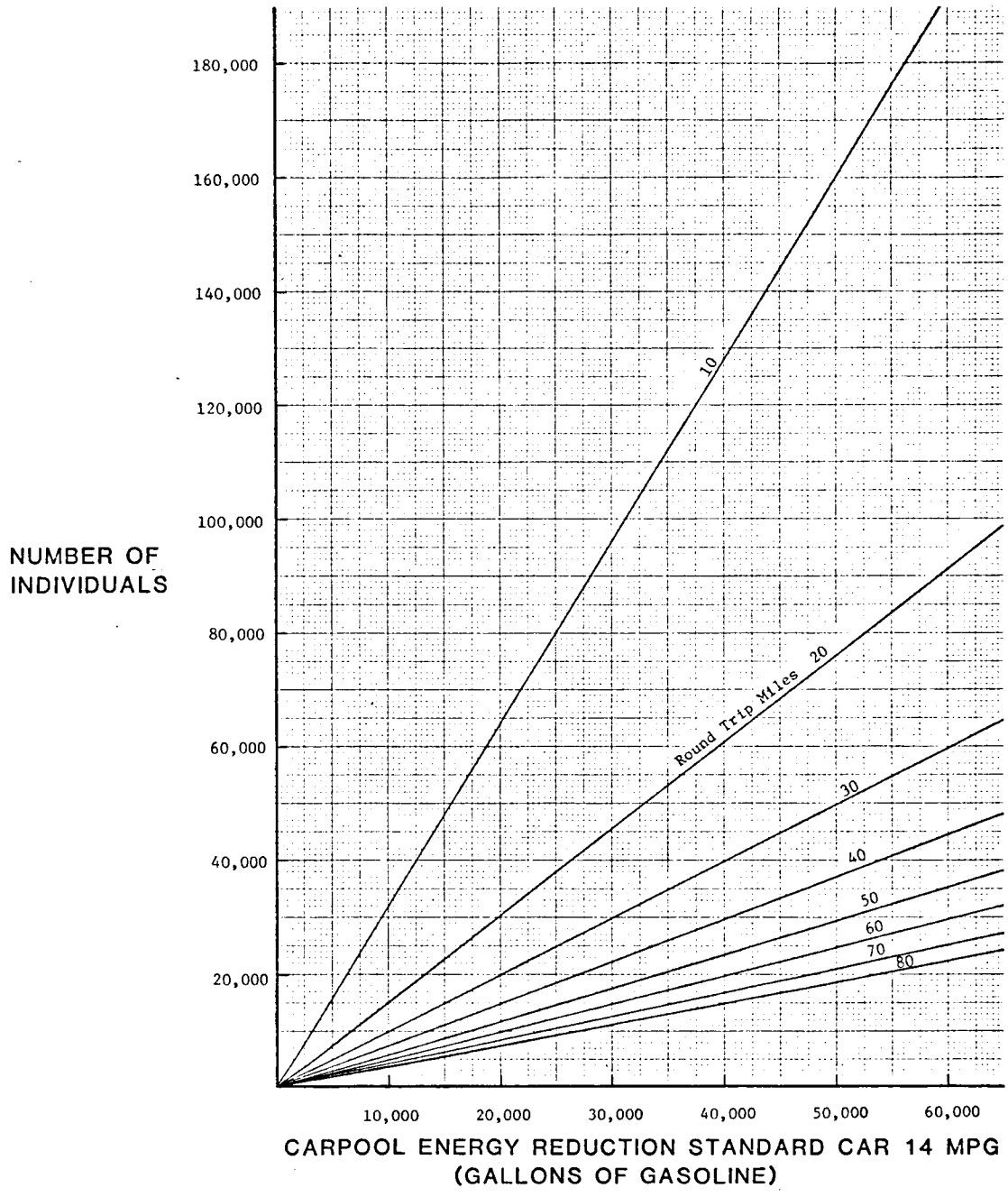


FIGURE C.3 NUMBER OF INDIVIDUALS NEEDED TO CARPOOL FOR REDUCTION IN ENERGY USAGE FOR STANDARD SIZE CAR

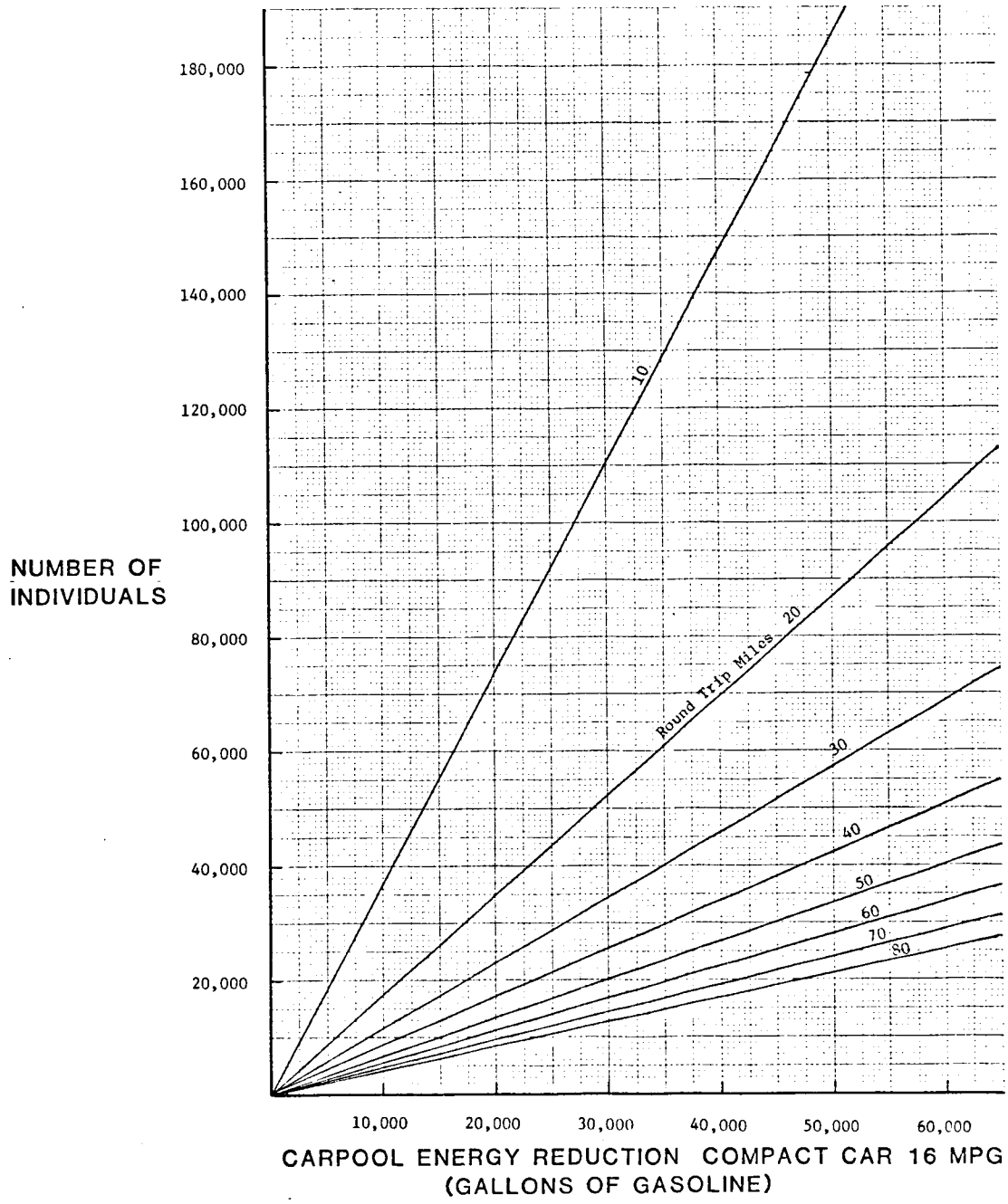


FIGURE C.4 NUMBER OF INDIVIDUALS NEEDED TO CARPOOL FOR REDUCTION IN ENERGY USAGE FOR COMPACT SIZE CAR

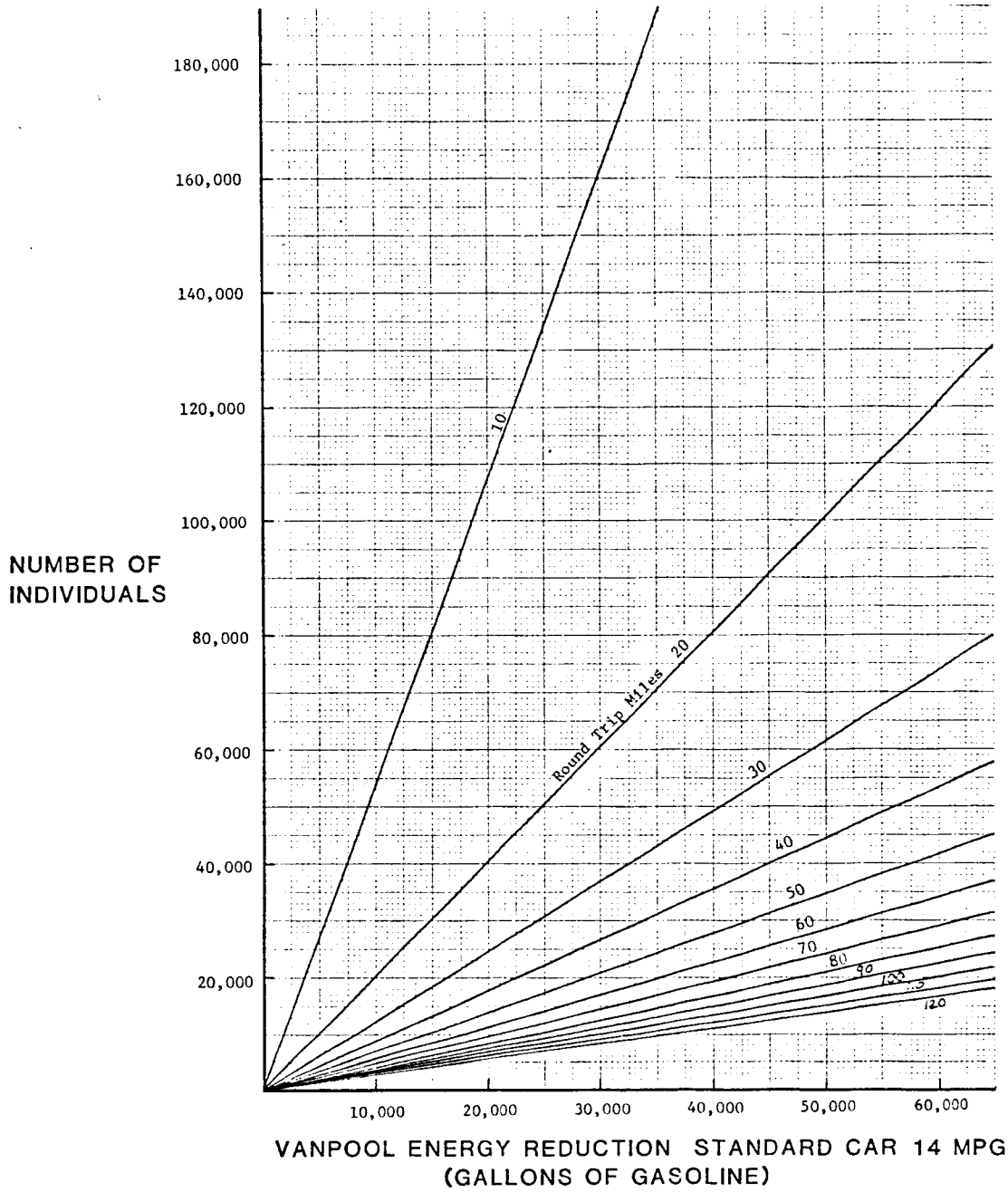


FIGURE C.5 NUMBER OF INDIVIDUALS NEEDED TO VANPOOL FOR REDUCTION IN ENERGY USAGE FOR STANDARD SIZE CAR

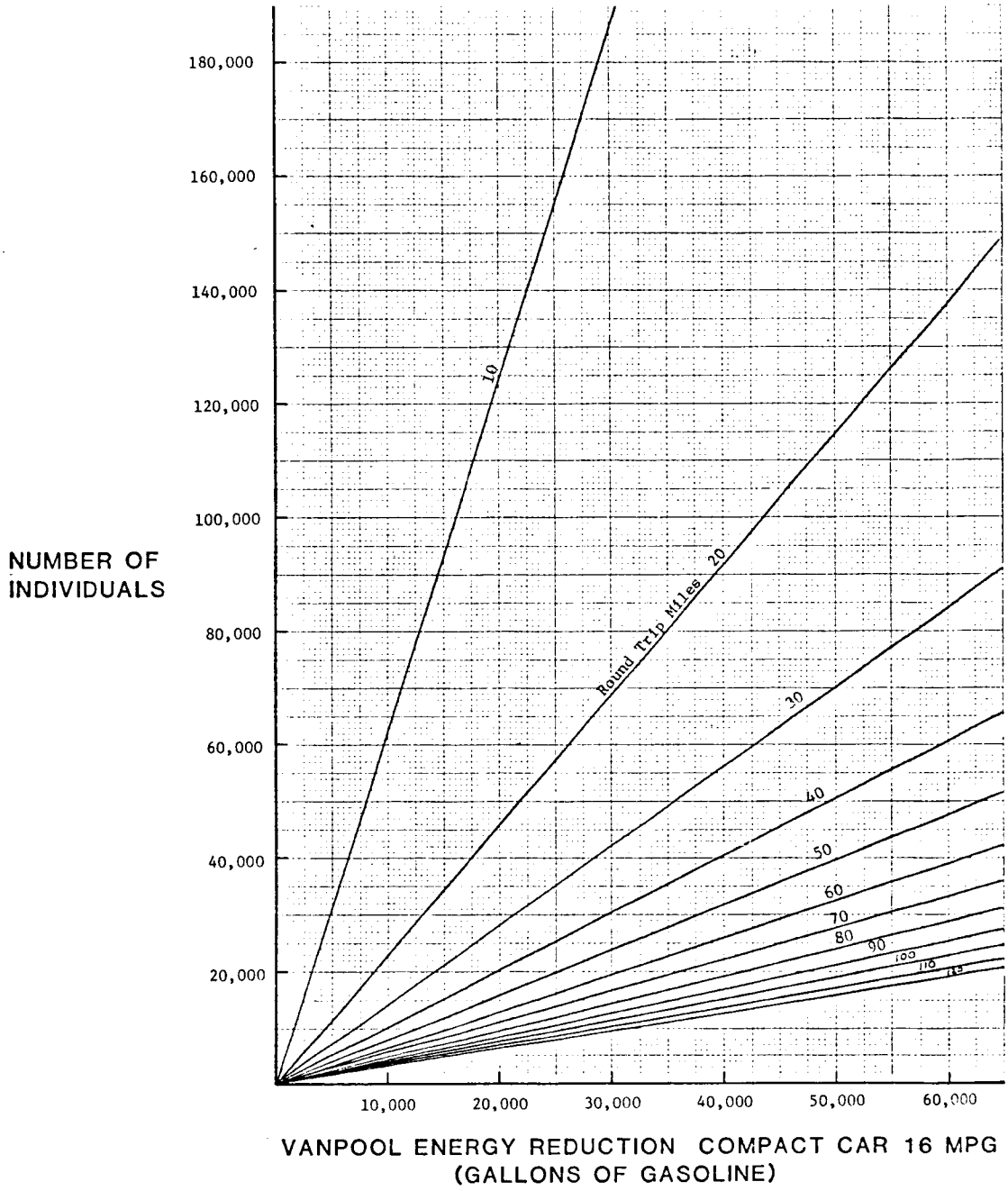


FIGURE C.6 NUMBER OF INDIVIDUALS NEEDED TO VANPOOL FOR REDUCTION IN ENERGY USAGE FOR COMPACT SIZE CAR

TABLE C.1 NUMBER OF INDIVIDUALS NEEDED TO CARPOOL FOR REDUCTION IN PARKING SPACES

Number of Parking Spaces To Be Reduced	Number of Individuals Needed to Carpool
100	200
250	500
500	1,000
1,000	2,000
2,000	4,000
3,000	6,000
4,000	8,000
5,000	10,000

TABLE C.2 NUMBER OF INDIVIDUALS NEEDED TO VANPOOL FOR REDUCTION IN PARKING SPACES

Number of Parking Spaces To Be Removed	Number of Individuals Needed to Vanpool
100	214
250	534
500	1,069
1,000	2,138
2,000	4,276
3,000	6,414
4,000	8,552
5,000	10,690

APPENDIX D

REGRESSION RESULTS OF DEMAND MODEL

TABLE D.1 INITIAL REGRESSION ANALYSIS UTILIZING COMBINED DATA SET AND DIFFERENCE IN TRAVEL COST VARIABLES (N398)

Step Number	Variable Entered	R - Square
1	HWTIME	.0266
2	DATC	.0473
3	SEX	.0711
4	NOVEH	.0879
5	RSTC	.0957
6	EMPPOP	.1004
7	DAPC	.1024
8	RSPC	.1377
9	RSOC	.1448
10	DAOC	.1534
11	HWDIST	.1553
12	WDENSY	.1568
13	AGE 3	.1572
14	AGE 2	.1612
15	AGE 4	.1618
16	HDENSY	.1620

TABLE D.2 INITIAL REGRESSION ANALYSIS UTILIZING COMBINED DATA SET AND SEPARATE VARIABLES FOR TRAVEL COST FOR EACH MODE
(N=398)

Step Number	Variable Entered	R - Square
1	HWTIME	.0266
2	SEX	.0459
3	NOVEH	.0623
4	DTCOST	.0777
5	EMPPOP	.0820
6	AGE 3	.0835
7	AGE 2	.0872
8	WDENSY	.0884
9	HDENSY	.0894
10	AGE 4	.0902
11	DOCOST	.0909
12	HWDIST	.0932
13	DPCOST	.0952

TABLE D.3 INITIAL REGRESSION ANALYSIS UTILIZING COMBINED DATA SET AND ACTUAL TRAVEL COST VARIABLES FOR EACH MODE (N=398)

Step Number	Variable Entered	R - Square
1	T COST	.2282
2	HWDIST	.4348
3	P COST	.5995
4	WDENSY	.6116
5	SEX	.6194
6	EMPPOP	.6249
7	O COST	.6309
8	NOVEH	.6348
9	HWTIME	.6353
10	Age 2	.6355
11	Age 3	.6398
12	Age 4	.6403
13	HDENSY	.6404

TABLE D.4 REGRESSION OF CBD EMPLOYEES

(N=430)

Step Number	Variable Entered	R - Square
1	P COST	.5146
2	O COST	.5346
3	HWDIST	.6649
4	SEX	.6741
5	NOVEH	.6763
6	AGE 4	.6787
7	WDENSY	.6789
8	T COST	.6790
9	HDENSY	.6791
10	HWTIME	.6791
11	Age 3	.6792
12	Age 2	.6792
13	EMPPOP	.6792

TABLE D.5 REGRESSION ANALYSIS OF NON-CBD EMPLOYEES

(N=366)

Step Number	Variable Entered	R - Square
1	T Cost	.1324
2	HWTIME	.4061
3	P COST	.5526
4	HWDIST	.6058
5	O COST	.6113
6	SEX	.6172
7	WDENSY	.6216
8	NOVEH	.6238
9	AGE 2	.6254
10	AGE 3	.6273
11	HDENSY	.6289
12	Age 4	.6299
13	EMPPOP 4	.6301

TABLE D.6 REGRESSION ANALYSIS EXCLUDING FAMILY CARPOOL MODE

Step Number	Variable Entered	R-Square
1	T COST	0.4195
2	HWTIME	0.6545
3	OCOST	0.7123
4	HWDIST	0.7698
5	CBD Dummy Variable	0.7774
6	SEX 1	0.7824
7	WDENSY	0.7854
8	HDENSY	0.7875
9	AGE 2	0.7885
10	NOVEH	0.7893
11	AGE 4	0.7898
12	Age 3	0.7903
13	EMPPOP	0.7908
14	P COST	0.7908

APPENDIX E

DOE MANUAL SKETCH PLANNING MODE SPLIT MODEL

APPENDIX E

DOE MANUAL SKETCH PLANNING MODE SPLIT MODEL

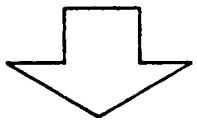
This appendix is broken into two parts, the first presents the sequence of calculations for applying the DOE manual method while the second presents three test applications for Knoxville, Tennessee.

Calculation Sequence

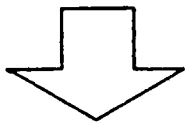
The sequence of steps for application of the methodology is illustrated in Figure E.1, with the specific outputs available from the travel demand analysis specified in Table E.1. Step 1 determines the level of detail for which the analysis is to be performed given the specified policy or policies to be examined and data availability, time, and budget constraints. The procedures are applicable for regional, corridor, or specific facility levels of detail, and are sensitive to a broad range of carpool, vanpool, and transit actions that may be considered.

Step 2 develops an appropriate classification system to account for the "differential" characteristics (or non-homogeneity) of the population subgroups affected by different policies. The relevant analysis population is divided into a number of discrete, more highly homogeneous classes; aggregate predictions for each subgroup then use mean values of travel modal shares and level-of-service changes for that specific group of the overall population. The total aggregate forecast is the weighted sum of the forecasts for each subgroup, where the weights are the percentages of the total population in each class.

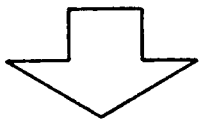
1. DETERMINE APPROPRIATE LEVEL OF ANALYSIS



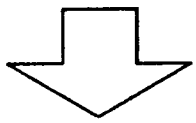
2. DETERMINE POPULATION GROUPS AFFECTED



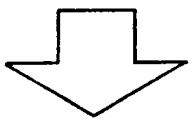
3 COLLECT BASE TRAVEL PATTERN DATA



4. TRANSLATE POLICY INTO TRANSPORTATION LEVEL-OF-SERVICE CHANGES



5. FORECAST REVISED WORK-TRIP MODAL SHARES



6. CALCULATE CHANGES IN VMT, AUTO OCCUPANCY, FUEL CONSUMPTION AND OTHER TRAVEL-RELATED VARIABLES

FIGURE E.1 BASIC TRAVEL DEMAND ANALYSIS OPERATIONS

TABLE E.1 TRAVEL DEMAND ANALYSIS OUTPUTS

Impact	Household Averages by: Population Subgroups	Total Population
Work Trip Modal Shares	X	X
Carpool Size	X	
Work-Trip Vehicle Miles of Travel (VMT) Per Day	X	
Percent Change	X	X
Non-Work Trip VMT Per Day	X	
Total VMT Per Day	X	
Percent Change	X	X

Step 3 defines the necessary base data on socioeconomic characteristics and travel patterns for each relevant population group including:

- Percent of total population analyzed;
- Average annual household income;
- Average number of nonwork auto trips daily;
- Base worktrips modal shares (drive alone, shared ride, and transit);
- Average carpool size;
- Average trip length (for work and nonwork trips); and
- Average daily vehicle miles of travel (VMT).

For policies differentiating between 2-person and 3-person carpools, additional data items required are:

- Base modal shares for 2-person and 3+person carpools; and
- Average size of 3+person carpools.

Step 4 translates the transportation policy analyzed into terms of changes in transportation level of service. For each mode, these include:

- In-vehicle travel time;
- Out-of-vehicle travel time (e.g., walk, wait, transfer, pickup, dropoff); and
- Out-of-pocket travel cost.

Step 5 predicts revised work trip modal shares for each population subgroup based on the changes in level of service defined in Step

4 and the base transportation data developed in Step 2. The forecast modal shares are based on the calculation of a "utility" function for each mode, which is then exponentiated and normalized to obtain an estimated change in modal share. Changes in the distribution of carpool size and the introduction of vanpooling as a new mode can be taken into consideration, if appropriate.

Step 6 uses these changes in work trip modal shares to calculate changes in work and non work vehicle miles traveled (VMT) and other travel related variables.

Basic Worksheets

The calculations necessary to analyze a transportation policy are defined on five basic worksheets, with supplemental worksheets provided for use in certain special situations. The basic forms include:

I. BASE DATA summarizes all household and travel related data necessary to perform the basic travel and energy calculations (Figure E.2).

II. CHANGES IN TRANSPORTATION LEVEL OF SERVICE summarizes all such changes which would result from implementation of the transportation policy to be analyzed (Figure E.3).

III. ESTIMATION OF REVISED WORK TRIP MODAL SHARES uses data from worksheets I and II to calculate rivised work trip modal shares for each transportation mode for each population group (Figure E.4).

IV. ESTIMATION OF CHANGES IN VMT uses results from worksheet III in conjunction with base data from worksheet I to calculate

I. BASE DATA

POLICY: _____

Population Subgroup											
Fraction of Total Population											
Average Household Data	Annual Income $										
	Number of Workers										
	Number of Non-Work Auto Trips										
Base Work Trip Modal Shares	Drive Alone										
	Shared Ride										
	Transit										
	Other										
Average Carpool Size											
Average Trip Length	Work (one way)										
	Non-Work (one way)										
Average Daily VMT	Work										
	Non-Work										
	Total										

FIGURE E.2 WORKSHEET I BASE DATA

II. CHANGES IN TRANSPORTATION LEVEL OF SERVICE (ROUND TRIP)

POLICY: _____

Transit	Out-of-Pocket Travel Cost $\triangle OPTC_t$ ¢									
	Out-of-Vehicle Travel Time $\triangle OVTT_t$ min.									
	In-Vehicle Travel Time $\triangle IVTT_t$ min.									
Shared Ride	Carpool Promotion & Matching Incentives 0,1									
	Out-of-Pocket Travel Cost $\triangle OPTC_{sr}$ ¢									
	Out-of-Vehicle Travel Time $\triangle OPTC_{sr}$ min.									
	In-Vehicle Travel Time $\triangle IVTT_{sr}$ min.									
Drive Alone	Out-of-Pocket Travel Cost $\triangle OPTC_{da}$ ¢									
	Out-of-Vehicle Travel Time $\triangle OVTT_{da}$ min.									
	In-Vehicle Travel Time $\triangle IVTT_{da}$ min.									
Population Subgroup										

FIGURE E.3 WORKSHEET II CHANGES IN TRANSPORTATION LEVEL OF SERVICE (ROUND TRIP)

III. ESTIMATION OF REVISED WORK-TRIP MODAL SHARES

POLICY: _____
SUBGROUP: _____

1. CHANGE IN UTILITY FOR EACH MODE

Drive Alone

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{da}] = [\quad]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{da}] = [\quad]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{da}] = [\quad]$

TOTAL CHANGE [ ]

Shared Ride

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{sr}] = [\quad]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{sr}] = [\quad]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{sr}] \div [\text{Average Car-pool Size}] = [\quad]$

$+ [.29] \times [\text{Incentives}] = [\quad]$

TOTAL CHANGE [ ]

Transit

$\Delta UTILITY = [-.015] \times [IVTT_t] = [\quad]$

$+ [-.16] \div [\text{Trip Length}] \times [OVTT_t] = [\quad]$

$+ [-29.0] \div [\text{Income}] \times [OPTC_t] = [\quad]$

TOTAL CHANGE [ ]

2. REVISED MODAL SHARE

	Base Modal Share		ΔUtility			Total	Revised Share
Drive Alone	[ ]	× EXP	[ ]	= [ ]	÷	[ ]	= [ ]
Shared Ride	[ ]	× EXP	[ ]	= [ ]	÷	[ ]	= [ ]
Transit	[ ]	× EXP	[ ]	= [ ]	÷	[ ]	= [ ]
Vanpool	[ ]	× EXP	[ ]	= [ ]	÷	[ ]	= [ ]
Other	[ ]	×	1.0	= [ ]	÷	[ ]	= [ ]
			Total	= [ ]			

FIGURE E.4 WORKSHEET III ESTIMATION OF REVISED WORK TRIP MODAL SHARES

changes in work trip and total VMT for each population class (Figure E.5).

V. SUMMARY OF ESTIMATED CHANGES IN VMT summarizes the travel changes calculated for each population group on worksheets IV to compute average areawide changes in VMT (Figure E.6).

While worksheets I, II, and V are used only once for each policy analysis, the calculation forms II and IV are repeated for each defined population classification. The sequence in which the five basic forms are used is detailed in Figure E.7. First, base household and travel data for all population groups analyzed are summarized on a single worksheet I and changes in transportation level of service on a single worksheet II. Calculations of changes in work trip modal shares are then performed separately for each group on worksheet III; worksheet IV translates these changes into changes in VMT. After all worksheet III and IV calculations have been completed for each population group, changes in work trip and total VMT are summarized and averaged on a single worksheet V.

Supplemental Worksheets

Five additional worksheets numbered according to their points of applicability in the base sequence are also provided:

- I-A BASE VMT uses data defined on worksheet I to calculate base household work, nonwork, and total vehicle miles of travel per day for each identified population subgroup. These items are then entered on worksheet I for subsequent

IV. ESTIMATION OF CHANGES IN VMT

POLICY _____

SUBGROUP _____

1. REVISED HOUSEHOLD WORK TRIP VMT

Revised Shared Ride Modal Share ÷ Revised Average Carpool Size + Revised Drive Alone Modal Share = Revised Autos Used Per Worker

Revised Autos Used per Worker × No. of Workers per Household × Work Trip Length × 2.0 = Auto VMT

Revised Vanpool Modal Share ÷ Average Vanpool Occupancy × No. of Workers per Household × Work Trip Length × Vanpool Circuity Factor × 2.0 = Vanpool VMT

Total Revised Household Work VMT

2. CHANGE IN HOUSEHOLD WORK TRIP VMT

Revised Household Work-Trip VMT − Base Work Trip VMT = Change in Work Trip VMT ÷ Base Work Trip VMT × 100 = % Change in Work Trip VMT

3. REVISED HOUSEHOLD NON-WORK TRIP VMT

(Base Autos Used per Worker − Revised Autos Used per Worker) × No. of Workers per Household = Change in Autos Remaining per Household

(Change in Autos Remaining per Household × .08 + 1.0) × Base Non-Work VMT = Revised Non-Work VMT

4. CHANGE IN TOTAL HOUSEHOLD VMT FROM BASE

Revised Work Trip VMT + Revised Non-Work VMT = Revised Total VMT

Change in Total VMT = Revised Total VMT − Base Total VMT

Change in Total VMT ÷ Base Total VMT × 100 = % Change in Total VMT

FIGURE E.5 WORKSHEET IV ESTIMATION OF CHANGES IN VMT

POLICY: _____

Population Subgroup	AVERAGE HOUSEHOLD VMT				X	Subgroup Fraction of Total Pop.	=	NORMALIZED HOUSEHOLD VMT				Percent Change in VMT	
	Work Trip VMT		Total VMT					Work Trip VMT		Total VMT			
	Base	△	Base	△				Base	△	Base	△	Work	Total
AVERAGE = $\sum$ = Subgroup													

	Average △VMT		Average VMT				% △VMT
Work Trip :		÷		X	100	=	
Total :		÷		X	100	=	

FIGURE E.6 WORKSHEET V SUMMARY OF CHANGES IN VMT

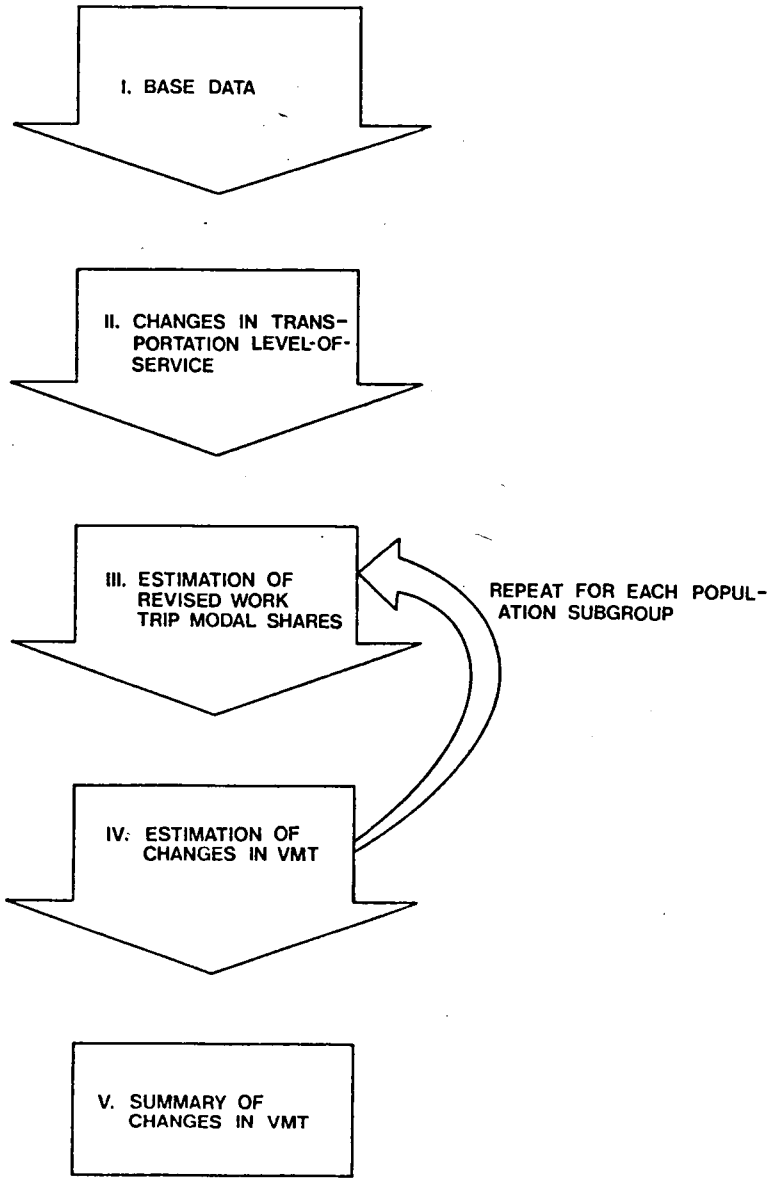


FIGURE E.7 SEQUENCE OF BASIC WORKSHEETS

use in the worksheet IV revised VMT calculations (Figure E.8).

- II-A CHANGES IN TRANSPORTATION LEVEL OF SERVICE BY CARPOOL SIZE identifies the additional travel data required for analyzing policies such as preferential treatment for 3-person carpools, that will have a major effect on the distribution of carpool size (e.g., converting existing 2-person carpools to 3+person carpools) in addition to the formation of entirely new carpools (Figure E.9).
- III-A ESTIMATION OF CHANGES IN CARPOOL SIZE uses data from worksheet II-A to calculate a revised carpool size distribution, changes in overall shared ride level of service, and a new average carpool size. This information is then utilized in subsequent worksheets II and IV calculations (Figure E.10).
- III-B ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING defines base vanpool data and estimates the changes that would occur in existing work trip modal shares that would result from introduction of a vanpool program. These results are then used on worksheet III, treating vanpooling as a new or fourth available mode (Figure E.11).
- V-A SUMMARY OF CHANGES IN MODAL SHARES uses the base and revised modal shares for each population group, taken from worksheets I and III respectively, to determine an average areawide change in the use of each transportation mode (Figure E.12).

I-A. BASE VMT

POLICY: _____

SUBGROUP: _____

1. BASE HOUSEHOLD WORK TRIP VMT

Base Shared Ride Modal Share		Base Average Carpool Size		Base Drive Alone Modal Share		Base Autos Used per Worker
	÷		+		=	

Base Autos Used per Workers		No. of Workers per Household		Work Trip Length		2.0	=	Base Household Work VMT
	X		X		X		=	

2. BASE HOUSEHOLD NON-WORK TRIP VMT

No. of Non-Work Auto Trips		Non-Work Trip Length		2.0	=	Base Household Non-Work VMT
	X		X		=	

3. BASE HOUSEHOLD TOTAL VMT

Base Household Work VMT		Base Household Non-Work VMT	=	Base Household Total VMT
	+		=	

FIGURE E.8 WORKSHEET I-A BASE VMT

II-A. CHANGES IN TRANSPORTATION LEVEL OF SERVICE BY CARPOOL SIZE

POLICY: _____

Changes in Transportation Level of Service (Round Trip)										
3+ Person Carpool	Promotion and Matching Incentives 0,1									
	Out-of-Pocket Travel Cost $\triangle OPTC_{3+}$									
	Out-of-Vehicle Travel Time $\triangle OVTT_{3+}$									
	In-Vehicle Travel Time $\triangle IVTT_{3+}$									
2 Person Carpool	Promotion and Matching Incentives 0,1									
	Out-of-Pocket Travel Cost $\triangle OPTC_2$ ¢									
	Out-of-Vehicle Travel Time $\triangle OVTT_2$ min.									
	In-Vehicle Travel Time $\triangle IVTT_2$ min.									
Average Size of 3+ Person Carpools										
Base Carpool-Size Shares	3+Person									
	2 Person									
Population Subgroup										

FIGURE E.9 WORKSHEET II-A CHANGES IN TRANSPORTATION LEVEL OF SERVICE BY CARPOOL SIZE

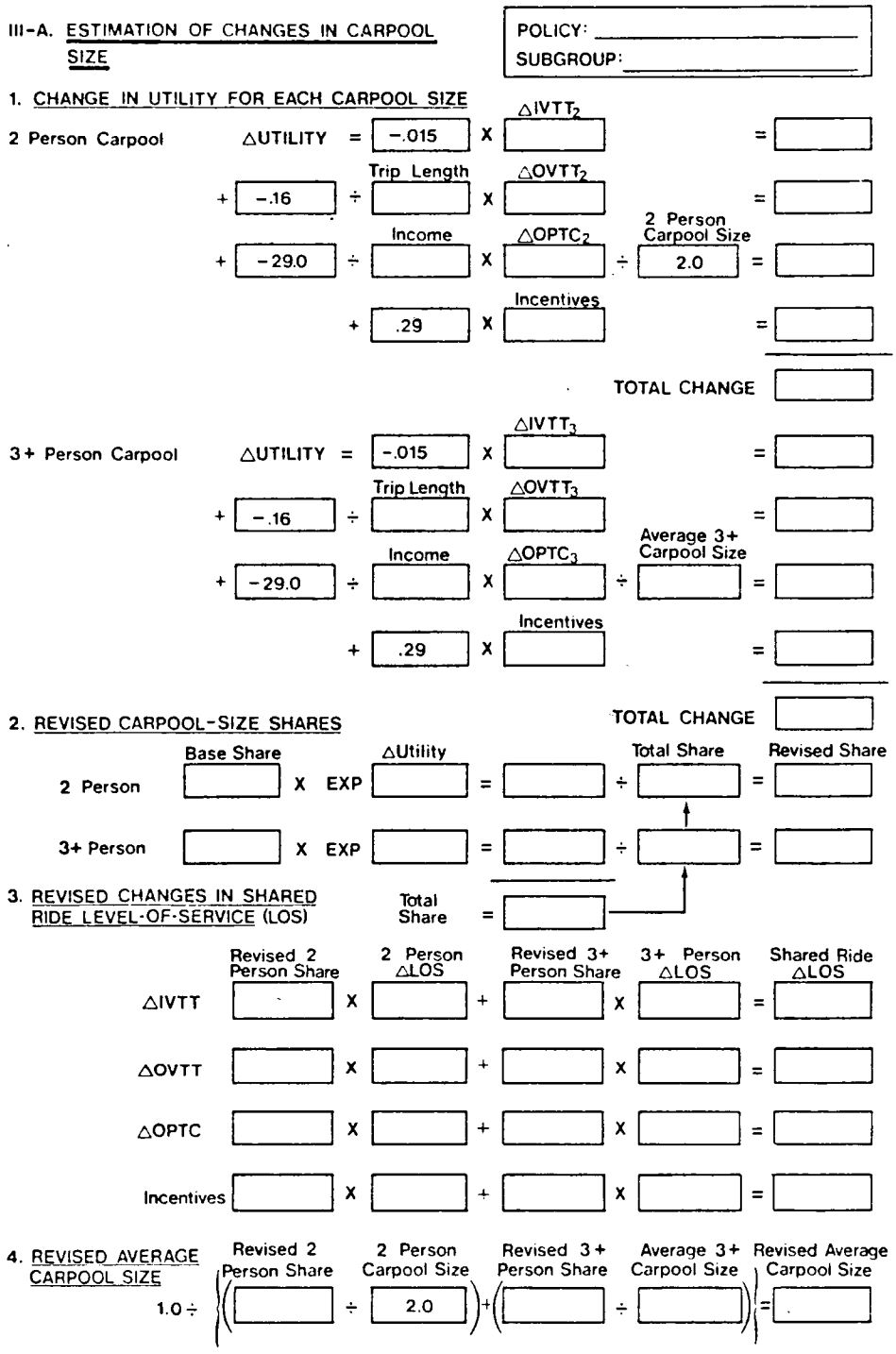


FIGURE E.10 WORKSHEET III-A ESTIMATION OF CHANGES IN CARPOOL SIZE

III-B. ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING

POLICY: _____

SUBGROUP: _____

1. BASE VANPOOL DATA

Vanpool Characteristics			Change in Vanpool Level of Service		
Estimated Vanpool Modal Share	Average Van-pool Occupancy	Circuity Factor	$\Delta IVTT_v$	$\Delta OVTT_v$	$\Delta OPTC$

2. REDUCTIONS IN MODAL SHARES

	Est. Vanpool Modal Share		Δ Transit Share		Base Transit Share		Δ Transit Share
Transit				X		=	
Drive Alone	Est. Vanpool Modal Share	−	Δ Transit Share	X	.5	=	Δ Drive Alone
Shared Ride		−		X	.5	=	Δ Shared Ride

3. REVISED MODAL SHARES

	Base Modal Share		Δ Modal Share		Revised Modal Sh
Transit		−		=	
Drive Alone		−		=	
Shared Ride		−		=	

4. CHANGE IN VANPOOL UTILITY

Δ UTILITY =	-.015	X	$\Delta IVTT_v$				=	
+	-.16	÷	Trip Length	X	$\Delta OVTT_v$		=	
+	-29.0	÷	Income	X	$\Delta OPTC_v$	÷ Average Van-pool Occupancy	=	
						TOTAL CHANGE		

FIGURE E.11 WORKSHEET III-B ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING

POLICY _____

Population Subgroup	AVERAGE MODAL SHARE										Fraction of Total Pop.	NORMALIZED MODAL SHARE									
	Drive Alone		Shared Ride		Transit		Other		Vanpooling			Drive Alone		Shared Ride		Transit		Other		Vanpooling	
	B*	R*	B	R	B	R	B	R	B	R		B	R	B	R	B	R	B	R	B	R

AVERAGE = $\sum$ = Subgroup

* B = Base
R = Revised

FIGURE E.12 WORKSHEET V-A SUMMARY OF CHANGES IN MODAL SHARES

The sequence of calculations including the use of these optional forms is given in Figure E.13. If changes in carpool size are to be analyzed, the supplementary data form worksheet II-A would be completed. When all necessary base data have been entered on the appropriate worksheets, calculations for estimating revised modal shares and changes in VMT are performed separately for each population class as in the base sequence; with the optional carpool size and vanpool modal share worksheets III-A and III-B also being used, as if appropriate, completed for each group. After the calculations on worksheets IV and V have been completed, the final optional form V-A can be used, if desired, to summarize changes in overall modal shares.

Test Applications

To demonstrate the application of the DOE manual method and test its transferability to a medium sized community, the methodology was applied to three different market segments in Knoxville, Tennessee where ridesharing incentives had been applied and results observed. The markets and applied strategies were: Union Carbide's three plants in nearby Oak Ridge, Tennessee, carpool matching and community wide vanpool program; Knoxville CBD, carpool matching and community wide vanpool program; and TVA headquarters in downtown Knoxville, carpool matching, employer vanpool program, express bus program and employer financial incentives for vanpool and express bus riders. These three test applications and the corresponding worksheets are presented in the following section.

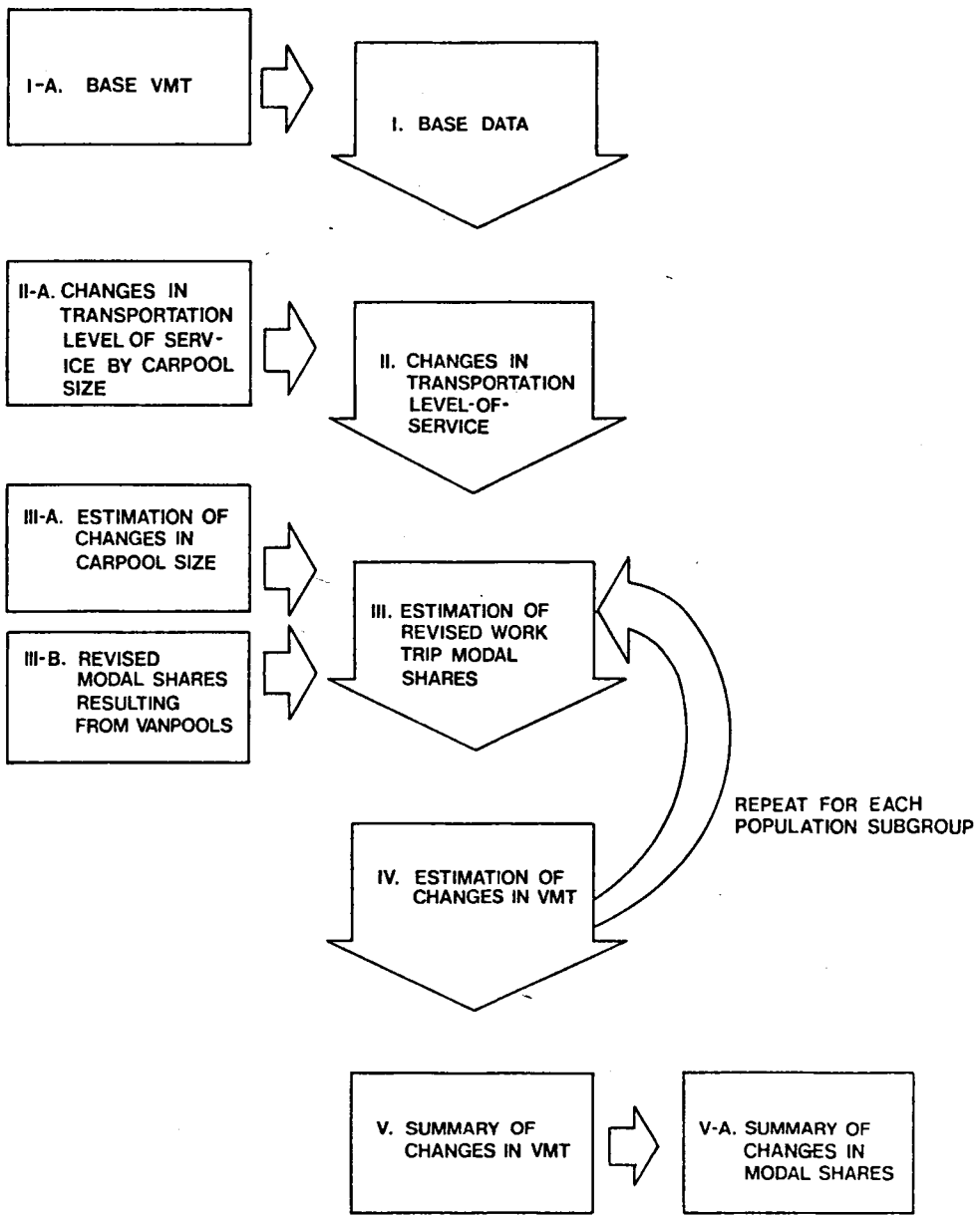


FIGURE E.13 SEQUENCE OF BASIC AND SUPPLEMENTAL WORKSHEETS

EXAMPLE APPLICATION 1

UNION CARBIDE

Type of Strategy: Carpool matching and community wide vanpool program.

Market Characteristics: Union Carbide operates three large plants employing approximately 17,000 individuals. The plants are located approximately 30 miles from Knoxville, TN in Oak Ridge, TN. The plants employ high technology workers with average incomes being one of the highest for the area.

Level of Analysis: Each plant was considered a separate analysis unit since travel distances and mode splits vary by plant. The proportion of commuters exposed and participating in the carpool matching program correspond to the porportion of commuters included in the analysis. Base travel data was collected through vehicle occupancy counts taken prior to implementation of the program.

POLICY: Carpool & Vanpool Programs

Population Subgroup	Fraction of Total Population	Average Household Data			Base Work Trip Modal Shares				Average Carpool Size	Average Trip Length		Average Daily VMT		
		Annual Income $	Number of Workers	Number of Non-Work Auto Trips	Drive Alone	Shared Ride	Transit	Other		Work (one way)	Non-Work (one way)	Work	Non-Work	Total
K-25	0.18		1.3	4.2	37.8	57.2	0	5	2.64	27	3	41.7	25.2	66.9
Y-12	0.01		1.3	4.2	53.8	41.2	0	5	2.47	25	3	45.8	25.2	71.0
X-10	0.13		1.3	4.2	37.4	57.6	0	5	2.82	25	3	37.6	25.2	62.8
NOT Participating	0.68		1.3	4.2	39.0	55.0	0	6	2.60	26	3	40.66	25.2	65.86

I-A. BASE VMT

POLICY: Carpool & Vanpool
SUBGROUP: K-25

1. BASE HOUSEHOLD WORK TRIP VMT

Base Shared Ride Modal Share		Base Average Carpool Size		Base Drive Alone Modal Share		Base Autos Used per Worker
0.572	÷	2.64	+	0.378	=	0.59

Base Autos Used per Workers		No. of Workers per Household		Work Trip Length				Base Household Work VMT
0.59	x	1.3	x	27	x	2.0	=	41.74

2. BASE HOUSEHOLD NON-WORK TRIP VMT

No. of Non-Work Auto Trips		Non-Work Trip Length				Base Household Non-Work VMT
4.2	x	3	x	2.0	=	25.2

3. BASE HOUSEHOLD TOTAL VMT

Base Household Work VMT		Base Household Non-Work VMT		Base Household Total VMT
41.74	+	25.2	=	66.94

II. CHANGES IN TRANSPORTATION LEVEL OF SERVICE (ROUND TRIP)

POLICY: Carpool / Vanpool Program

Transit	Out-of-Pocket Travel Cost $\Delta OPTC_t$ ¢									
	Out-of-Vehicle Travel Time $\Delta OVTT_t$ min.									
	In-Vehicle Travel Time $\Delta IVTT_t$ min.									
Shared Ride	Carpool Promotion & Matching Incentives $_{0,1}$	+1.0	+1.0	+1.0						
	Out-of-Pocket Travel Cost $\Delta OPTC_{sr}$ ¢									
	Out-of-Vehicle Travel Time $\Delta OPTC_{sr}$ min.									
	In-Vehicle Travel Time $\Delta IVTT_{sr}$ min.									
Drive Alone	Out-of-Pocket Travel Cost $\Delta OPTC_{da}$ ¢									
	Out-of-Vehicle Travel Time $\Delta OVTT_{da}$ min.									
	In-Vehicle Travel Time $\Delta IVTT_{da}$ min.									
Population Subgroup		K-25	Y-12	X-10						

III. ESTIMATION OF REVISED WORK-TRIP MODAL SHARES

POLICY: Carpool & Vanpool
SUBGROUP: K-25

1. CHANGE IN UTILITY FOR EACH MODE

Drive Alone

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{da}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{da}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{da}] = [\ ]$

TOTAL CHANGE [ ]

Shared Ride

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{sr}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{sr}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{sr}] \div [\text{Average Car-pool Size}] = [\ ]$

$+ [.29] \times [\text{Incentives } +1.0] = [+0.29]$

TOTAL CHANGE [+0.29]

Transit

$\Delta UTILITY = [-.015] \times [IVTT_t] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [OVTT_t] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [OPTC_t] = [\ ]$

TOTAL CHANGE [ ]

2. REVISED MODAL SHARE

	Base Modal Share		ΔUtility			Total		Revised Share
Drive Alone	= 0.328	× EXP	0.0	=	0.328	÷ 1.18	=	0.278
Shared Ride	= 0.522	× EXP	+0.29	=	0.70	÷ 1.18	=	0.595
Transit	= 0.0	× EXP	0.0	=	0.0	÷ 1.18	=	0.0
Vanpool	= 0.12	× EXP	0.0	=	0.12	÷ 1.18	=	0.102
Other	= 0.03	×	1.0	=	0.03	÷ 1.18	=	0.025
			Total	=	1.18			

III-B. ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING

POLICY: Carpool & Vanpool
SUBGROUP: K-25

1. BASE VANPOOL DATA

Vanpool Characteristics			Change in Vanpool Level of Service		
Estimated Vanpool Modal Share	Average Vanpool Occupancy	Circuity Factor	$\Delta IVTT_v$	$\Delta OVTT_v$	$\Delta OPTC_v$
0.10	11	1.5	0.0	0.0	0.0

2. REDUCTIONS IN MODAL SHARES

	Est. Vanpool Modal Share		ΔTransit Share		Base Transit Share		ΔTransit Share
Transit			0.10	x	0.0	=	0.0
Drive Alone	0.10	-	0.0	x	.5	=	ΔDrive Alone 0.05
Shared Ride	0.10	-	0.0	x	.5	=	ΔShared Ride 0.05

3. REVISED MODAL SHARES

	Base Modal Share		ΔModal Share		Revised Modal Share
Transit	0.0	-	0.0	=	0.0
Drive Alone	0.378	-	0.05	=	0.328
Shared Ride	0.572	-	0.05	=	0.522

4. CHANGE IN VANPOOL UTILITY

ΔUTILITY =	-.015	x	$\Delta IVTT_v$ 0.0			=	0.0
+	-.16	÷	Trip Length	x	$\Delta OVTT_v$ 0.0		=	0.0
+	-29.0	÷	Income	x	$\Delta OPTC_v$ 0.0	÷ Average Vanpool Occupancy 11	=	0.0
						TOTAL CHANGE		0.0

IV. ESTIMATION OF CHANGES IN VMT

POLICY Carpool & Vanpool
SUBGROUP K-25

1. REVISED HOUSEHOLD WORK TRIP VMT

Revised Shared Ride Modal Share		Revised Average Carpool Size		Revised Drive Alone Modal Share		Revised Autos Used Per Worker
0.595	÷	2.64	+	0.278	=	0.503

Revised Autos Used per Worker		No. of Workers per Household		Work Trip Length				Auto VMT
0.503	x	1.3	x	27	x	2.0	=	35.34

Revised Vanpool Modal Share		Average Vanpool Occupancy		No. of Workers per Household		Work Trip Length		Vanpool Circuity Factor				Vanpool VMT
0.085	÷	11	x	1.3	x	27	x	1.5	x	2.0	=	0.81

Total Revised Household Work VMT
36.15

2. CHANGE IN HOUSEHOLD WORK TRIP VMT

Revised Household Work-Trip VMT		Base Work Trip VMT		Change in Work Trip VMT		Base Work Trip VMT				% Change in Work Trip VMT
36.15	−	41.74	=	-5.59	÷	41.74	x	100	=	-13.4

3. REVISED HOUSEHOLD NON-WORK TRIP VMT

Base Autos Used per Worker		Revised Autos Used per Worker		No. of Workers per Household		Change in Autos Remaining per Household
0.59	−	0.503	x	1.3	=	0.12

Change in Autos Remaining per Household						Base Non-Work VMT		Revised Non-Work VMT
0.12	x	.08	+	1.0	x	25.2	=	25.4

4. CHANGE IN TOTAL HOUSEHOLD VMT FROM BASE

Revised Work Trip VMT		Revised Non-Work VMT		Revised Total VMT
36.15	+	25.4	=	61.55

Base Total VMT: 66.94

Change in Total VMT						% Change in Total VMT
-5.39	÷	66.94	x	100	=	-8.05

POLICY: Carpool & Vanpool

V. SUMMARY OF CHANGES IN VMT

Population Subgroup	AVERAGE HOUSEHOLD VMT				X	Subgroup Fraction of Total Pop.	=	NORMALIZED HOUSEHOLD VMT				Percent Change in VMT	
	Work Trip VMT		Total VMT					Work Trip VMT		Total VMT			
	Base	Δ	Base	Δ				Base	Δ	Base	Δ	Work	Total
K-25	41.74	-5.59	66.94	-5.39		.1787		7.46	-0.99	11.96	-0.96	-13.4	-8.05
Y-12	45.81	-5.42	71.01	-5.17		.009		0.412	-0.049	0.639	-0.47	-11.82	-7.28
X-10	37.65	-5.26	62.85	-5.02		.1274		4.80	-0.67	8.01	-0.64	-13.97	-7.98
Not Particpat	40.66	—	65.86	—		.6849		27.85	0.0	45.11	0.0	—	—
AVERAGE = $\sum$ Subgroup							=	40.52	-1.71	65.72	-1.65		

	Average ΔVMT		Average VMT			% ΔVMT
Work Trip :	-1.71	÷	40.52	x	100	= -4.22
Total :	-1.65	÷	65.72	x	100	= -2.51

EXAMPLE APPLICATION 2

KNOXVILLE CENTRAL BUSINESS DISTRICT

Type of Strategy: Carpool matching and community wide vanpool program.

Market Characteristics: The Knoxville CBD contains approximately 20,000 employees ranging in employment types from banking, office, and commercial establishments to warehousing and light manufacturing firms.

Level of Analysis: The analysis area was divided into three groups based upon the availability of travel modes and commute travel distances. The three groups are: (1) rideshare and transit available; (2) drive alone, rideshare, and transit available; and (3) rideshare, drive alone, and vanpool available. Base travel data was determined through vehicle occupancy surveys conducted throughout the CBD and various surveys of travel data. In the analysis, TVA employees were not included since they are addressed as a separate market segment in the third example application.

POLICY: Carpool & Vanpool Program

	Population Subgroup	Fraction of Total Population	Average Household Data			Base Work Trip Modal Shares				Average Carpool Size	Average Trip Length		Average Daily VMT		
			Annual Income $	Number of Workers	Number of Non-Work Auto Trips	Drive Alone	Shared Ride	Transit	Other		Work (one way)	Non-Work (one way)	Work	Non-Work	Total
(1)	Rideshare & Transit Available	0.12		1.3	0	0.0	0.50	0.35	0.15	2.2	7	3	4.14	0	4.14
(2)	Drive Alone, Rideshare, & Transit	0.70		1.3	4.2	0.62	0.29	0.07	0.02	2.2	9	3	17.59	25.2	42.79
(3)	Rideshare, Drive Alone, & Vanpool	0.18		1.3	4.2	0.63	0.35	0.0	0.02	2.5	20	4	39.83	33.6	73.43

I-A. BASE VMT

POLICY: Carpool & Vanpool
SUBGROUP: 3: Rideshare, Drive Alone, Vanpool

1. BASE HOUSEHOLD WORK TRIP VMT

Base Shared Ride Modal Share		Base Average Carpool Size		Base Drive Alone Modal Share		Base Autos Used per Worker
0.35	÷	2.5	+	0.63	=	0.77

Base Autos Used per Workers		No. of Workers per Household		Work Trip Length				Base Household Work VMT
0.77	x	1.3	x	20	x	2.0	=	39.83

2. BASE HOUSEHOLD NON-WORK TRIP VMT

No. of Non-Work Auto Trips		Non-Work Trip Length				Base Household Non-Work VMT
4.2	x	4	x	2.0	=	33.6

3. BASE HOUSEHOLD TOTAL VMT

Base Household Work VMT		Base Household Non-Work VMT		Base Household Total VMT
39.83	+	33.6	=	73.43

II. CHANGES IN TRANSPORTATION LEVEL OF SERVICE (ROUND TRIP)

POLICY: Carpool / Vanpool / Program

Transit	Out-of-Pocket Travel Cost $\triangle OPTC_t$ ¢									
	Out-of-Vehicle Travel Time $\triangle OVTT_t$ min.									
	In-Vehicle Travel Time $\triangle IVTT_t$ min.									
Shared Ride	Carpool Promotion & Matching Incentives 0,1	+1.0	+1.0	+1.0						
	Out-of-Pocket Travel Cost $\triangle OPTC_{sr}$ ¢									
	Out-of-Vehicle Travel Time $\triangle OPTC_{sr}$ min.									
	In-Vehicle Travel Time $\triangle IVTT_{sr}$ min.									
Drive Alone	Out-of-Pocket Travel Cost $\triangle OPTC_{da}$ ¢									
	Out-of-Vehicle Travel Time $\triangle OVTT_{da}$ min.									
	In-Vehicle Travel Time $\triangle IVTT_{da}$ min.									
Population Subgroup		1	2	3						

III. ESTIMATION OF REVISED WORK-TRIP MODAL SHARES

POLICY: Carpool & Vanpool
SUBGROUP: 3: Rideshare, Drive Alone, Vanpool

1. CHANGE IN UTILITY FOR EACH MODE

Drive Alone

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{da}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{da}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{da}] = [\ ]$

TOTAL CHANGE [ ]

Shared Ride

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{sr}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{sr}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{sr}] \div [\text{Average Car-pool Size}] = [\ ]$

$+ [.29] \times [\text{Incentives } +1.0] = [+0.29]$

TOTAL CHANGE [+0.29]

Transit

$\Delta UTILITY = [-.015] \times [IVTT_t] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [OVTT_t] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [OPTC_t] = [\ ]$

TOTAL CHANGE [ ]

2. REVISED MODAL SHARE

	Base Modal Share		ΔUtility			Total	Revised Share
Drive Alone	= [0.59]	× EXP	[0.0]	= [0.59]	÷	[1.11]	= [0.53]
Shared Ride	= [0.31]	× EXP	[+0.29]	= [0.42]	÷	[1.11]	= [0.38]
Transit	= [0.0]	× EXP	[0.0]	= [0.0]	÷	[1.11]	= [0.0]
Vanpool	= [0.08]	× EXP	[0.0]	= [0.08]	÷	[1.11]	= [0.07]
Other	= [0.02]	×	1.0	= [0.02]	÷	[1.11]	= [0.02]
			Total	= [1.11]			

III-B. ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING

POLICY: Carpool & Vanpool
SUBGROUP: 3: Rideshare, Drive Alone / Vanpool

1. BASE VANPOOL DATA

Vanpool Characteristics			Change in Vanpool Level of Service		
Estimated Vanpool Modal Share	Average Vanpool Occupancy	Circuity Factor	$\Delta IVTT_v$	$\Delta OVTT_v$	$\Delta OPTC_v$
0.08	11	1.5	0.0	0.0	0.0

2. REDUCTIONS IN MODAL SHARES

	Est. Vanpool Modal Share		ΔTransit Share		Base Transit Share		ΔTransit Share
Transit			0.08	x	0.0	=	0.0
	Est. Vanpool Modal Share		ΔTransit Share				ΔDrive Alone
Drive Alone	0.08	-	0.0	x	.5	=	0.04
							ΔShared Ride
Shared Ride	0.08	-	0.0	x	.5	=	0.04

3. REVISED MODAL SHARES

	Base Modal Share		ΔModal Share		Revised Modal Share
Transit	0.0	-	0.0	=	0.0
Drive Alone	0.63	-	0.04	=	0.59
Shared Ride	0.35	-	0.04	=	0.31

4. CHANGE IN VANPOOL UTILITY

ΔUTILITY =	-.015	x	$\Delta IVTT_v$ 0.0			=	0.0
+	-.16	÷	Trip Length	x	$\Delta OVTT_v$ 0.0			=	0.0
+	-29.0	÷	Income	x	$\Delta OPTC_v$ 0.0	÷	Average Vanpool Occupancy 11	=	0.0
							TOTAL CHANGE		0.0

IV. ESTIMATION OF CHANGES IN VMT

POLICY Carpool & Vanpool
SUBGROUP 3: Rideshare, Drive Alone, Vanpool

1. REVISED HOUSEHOLD WORK TRIP VMT

Revised Shared Ride Modal Share		Revised Average Carpool Size		Revised Drive Alone Modal Share		Revised Autos Used Per Worker
0.38	÷	2.5	+	0.53	=	0.682

Revised Autos Used per Worker		No. of Workers per Household		Work Trip Length			=	Auto VMT
0.682	x	1.3	x	20	x	2.0	=	35.46

Revised Vanpool Modal Share		Average Vanpool Occupancy		No. of Workers per Household		Work Trip Length		Vanpool Circuity Factor			=	Vanpool VMT
0.07	÷	11	x	1.3	x	20	x	1.5	x	2.0	=	0.50

Total Revised Household Work VMT
35.96

2. CHANGE IN HOUSEHOLD WORK TRIP VMT

Revised Household Work-Trip VMT		Base Work Trip VMT		Change in Work Trip VMT		Base Work Trip VMT			=	% Change in Work Trip VMT
35.96	−	39.83	=	-3.87	÷	39.83	x	100	=	-9.7

3. REVISED HOUSEHOLD NON-WORK TRIP VMT

Base Autos Used per Worker		Revised Autos Used per Worker		No. of Workers per Household		Change in Autos Remaining per Household
0.77	−	0.682	x	1.3	=	0.114

Change in Autos Remaining per Household					Base Non-Work VMT		Revised Non-Work VMT
0.114	x	.08	+	1.0	x	33.6	= 33.91

4. CHANGE IN TOTAL HOUSEHOLD VMT FROM BASE

Revised Work Trip VMT		Revised Non-Work VMT		Revised Total VMT
35.96	+	33.91	=	69.87

Base Total VMT: − 73.43

Change in Total VMT						% Change in Total VMT
-3.56	÷	73.43	x	100	=	-4.85

POLICY: Carpool & Vanpool

Population Subgroup	AVERAGE HOUSEHOLD VMT				X	Subgroup Fraction of Total Pop.	=	NORMALIZED HOUSEHOLD VMT				Percent Change in VMT	
	Work Trip VMT		Total VMT					Work Trip VMT		Total VMT			
	Base	Δ	Base	Δ				Base	Δ	Base	Δ	Work	Total
1	4.14	+0.58	4.14	+0.58		0.12		0.497	+0.069	0.497	+0.069	+13.9	+13.9
2	17.59	-0.66	42.79	-0.58		0.70		12.31	-0.46	29.95	-0.406	-3.73	-1.35
3	39.83	-3.87	73.43	-3.56		0.18		7.17	-0.69	13.22	-0.64	-9.7	-4.85
AVERAGE						$=\sum$ Subgroup	=	19.98	-1.08	43.65	-0.98		

V. SUMMARY OF CHANGES IN VMT

	Average ΔVMT		Average VMT			% ΔVMT
Work Trip :	-1.08	÷	19.98	x	100	= -5.4
Total :	-0.98	÷	43.65	x	100	= -2.2

EXAMPLE APPLICATION 3

TENNESSEE VALLEY HEADQUARTERS, KNOXVILLE TENNESSEE

Type of Strategy: Carpool matching, employer vanpool program, express bus program, employer financial incentives for vanpool and express bus riders; $0.57 per day for van riders and $0.20 per day for express bus riders.

Market Characteristics: TVA's headquarters are located in downtown Knoxville and employes approximately 4,200 individuals. The work force is comprised of management and technical staff with salaries being one of the highest in the area.

Level of Analysis: The analysis area was divided into three groups based upon the availability of travel modes and commute travel distances. The three groups are: (1) rideshare, express bus, drive alone, and vanpool available; (2) rideshare, and regular transit available; and (3) rideshare, drive alone, and regular transit. Base travel data was determined through a survey of employees prior to implementation of the ridesharing program.

POLICY: CPt UP Program, Employer Financial Incentives

I. BASE DATA

	Population Subgroup	Fraction of Total Population	Average Household Data: Annual Income $	Average Household Data: Number of Workers	Average Household Data: Number of Non-Work Auto Trips	Base Work Trip Modal Shares: Drive Alone	Base Work Trip Modal Shares: Shared Ride	Base Work Trip Modal Shares: Transit	Base Work Trip Modal Shares: Other	Average Carpool Size	Average Trip Length: Work (one way)	Average Trip Length: Non-Work (one way)	Average Daily VMT: Work	Average Daily VMT: Non-Work	Average Daily VMT: Total
(1)	Rideshare, Express Bus, Drive Alone Vanpool	0.55	17,000	1.3	4.2	0.66	0.32	0.02	0.0	2.5	20	4	40.98	33.60	74.58
(2)	Rideshare Regular Transit	0.07	13,000	1.3	0	0.0	0.50	0.50	0.0	2.2	7	3	4.14	0.0	4.14
(3)	Rideshare, Drive Alone, Reg. Trans.	0.38	17,000	1.3	4.2	0.69	0.27	0.04	0.0	2.2	9	3	18.95	25.2	44.15

I-A. BASE VMT

POLICY: CP & VP, Employer Financial Incentives
SUBGROUP: (1) RS, EB, DA, VP

1. BASE HOUSEHOLD WORK TRIP VMT

Base Shared Ride Modal Share		Base Average Carpool Size		Base Drive Alone Modal Share		Base Autos Used per Worker
0.32	÷	2.5	+	0.66	=	0.79

Base Autos Used per Workers		No. of Workers per Household		Work Trip Length				Base Household Work VMT
0.79	x	1.3	x	20	x	2.0	=	40.98

2. BASE HOUSEHOLD NON-WORK TRIP VMT

No. of Non-Work Auto Trips		Non-Work Trip Length				Base Household Non-Work VMT
4.2	x	4	x	2.0	=	33.60

3. BASE HOUSEHOLD TOTAL VMT

Base Household Work VMT		Base Household Non-Work VMT		Base Household Total VMT
40.98	+	33.60	=	74.58

POLICY: cpl up Employer Financial Incentives

II. CHANGES IN TRANSPORTATION LEVEL OF SERVICE (ROUND TRIP)

Transit	Out-of-Pocket Travel Cost $\Delta OPTC_t$ ¢	-0.20								
	Out-of-Vehicle Travel Time $\Delta OVTT_t$ min.									
	In-Vehicle Travel Time $\Delta IVTT_t$ min.									
Shared Ride	Carpool Promotion & Matching Incentives 0,1	+1.0	+1.0	+1.0						
	Out-of-Pocket Travel Cost $\Delta OPTC_{sr}$ ¢	-0.57								
	Out-of-Vehicle Travel Time $\Delta OPTC_{sr}$ min.									
	In-Vehicle Travel Time $\Delta IVTT_{sr}$ min.									
Drive Alone	Out-of-Pocket Travel Cost $\Delta OPTC_{da}$ ¢									
	Out-of-Vehicle Travel Time $\Delta OVTT_{da}$ min.									
	In-Vehicle Travel Time $\Delta IVTT_{da}$ min.									
Population Subgroup		1	2	3						

III. ESTIMATION OF REVISED WORK-TRIP MODAL SHARES

POLICY: CP & VP, Employer Financial Incentives
SUBGROUP: ① RS, EB, DA, VP

1. CHANGE IN UTILITY FOR EACH MODE

Drive Alone

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{da}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{da}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{da}] = [\ ]$

TOTAL CHANGE [ ]

Shared Ride

$\Delta UTILITY = [-.015] \times [\Delta IVTT_{sr}] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [\Delta OVTT_{sr}] = [\ ]$

$+ [-29.0] \div [\text{Income}] \times [\Delta OPTC_{sr}] \div [\text{Average Car-pool Size}] = [\ ]$

$+ [.29] \times [\text{Incentives } +1.0] = [+0.29]$

TOTAL CHANGE [+0.29]

Transit

$\Delta UTILITY = [-.015] \times [IVTT_t] = [\ ]$

$+ [-.16] \div [\text{Trip Length}] \times [OVTT_t] = [\ ]$

$+ [-29.0] \div [17,000] \times [\text{Income } -0.20] = [+0.034]$

TOTAL CHANGE [+0.034]

2. REVISED MODAL SHARE

	Base Modal Share		ΔUtility		Total	Revised Share
Drive Alone	= 0.56 × EXP	0.0	= 0.56	÷	1.07	= 0.52
Shared Ride	= 0.22 × EXP	+0.29	= 0.30	÷	1.07	= 0.28
Transit	= 0.02 × EXP	+0.034	= 0.02	÷	1.07	= 0.02
Vanpool	= 0.20 × EXP	-0.066	= 0.19	÷	1.07	= 0.18
Other	= 0.0 ×	1.0	= 0.0	÷	1.07	= 0.0
		Total	= 1.07			

III-B. ESTIMATION OF REVISED MODAL SHARES RESULTING FROM VANPOOLING

POLICY: CP4 VP, Employer Financial Incentives
SUBGROUP: ① RS, EB, DA, VP

1. BASE VANPOOL DATA

Vanpool Characteristics			Change in Vanpool Level of Service		
Estimated Vanpool Modal Share	Average Vanpool Occupancy	Circuity Factor	$\Delta IVTT_v$	$\Delta OVTT_v$	$\Delta OPTC$
0.20	11	1.5	+5	0.0	-0.57

2. REDUCTIONS IN MODAL SHARES

	Est. Vanpool Modal Share		ΔTransit Share		Base Transit Share		ΔTransit Share
Transit			0.20	x	.02	=	.004
	Est. Vanpool Modal Share		ΔTransit Share				ΔDrive Alone
Drive Alone	0.20	-	0.004	x	.5	=	0.10
							ΔShared Ride
Shared Ride	0.20	-	0.004	x	.5	=	0.10

3. REVISED MODAL SHARES

	Base Modal Share		ΔModal Share		Revised Modal Share
Transit	0.02	-	0.0	=	0.02
Drive Alone	0.66	-	0.10	=	0.56
Shared Ride	0.32	-	0.10	=	0.22

4. CHANGE IN VANPOOL UTILITY

ΔUTILITY =	-.015	x	$\Delta IVTT_v$ +5			=	-0.075
+	-.16	÷	Trip Length	x	$\Delta OVTT_v$	=	
+	-29.0	÷	Income 17,000	x	$\Delta OPTC_v$ -57	÷ Average Vanpool Occupancy 11	=	+0.009
						TOTAL CHANGE		-0.066

IV. ESTIMATION OF CHANGES IN VMT

POLICY CP & VP, Employer Financial Incentives
SUBGROUP (1) RS, EB, DA, VP

1. REVISED HOUSEHOLD WORK TRIP VMT

Revised Shared Ride Modal Share		Revised Average Carpool Size		Revised Drive Alone Modal Share		Revised Autos Used Per Worker
0.28	÷	2.5	+	0.52	=	0.63

Revised Autos Used per Worker		No. of Workers per Household		Work Trip Length				Auto VMT
0.63	x	1.3	x	20	x	2.0	=	32.86

Revised Vanpool Modal Share		Average Vanpool Occupancy		No. of Workers per Household		Work Trip Length		Vanpool Circuity Factor				Vanpool VMT
0.18	÷	11	x	1.3	x	20	x	1.5	x	2.0	=	1.28

Total Revised Household Work VMT
34.14

2. CHANGE IN HOUSEHOLD WORK TRIP VMT

Revised Household Work-Trip VMT		Base Work Trip VMT		Change in Work Trip VMT		Base Work Trip VMT			% Change in Work Trip VMT
34.14	−	40.98	=	-6.84	÷	40.98	x	100	= -16.70

3. REVISED HOUSEHOLD NON-WORK TRIP VMT

Base Autos Used per Worker		Revised Autos Used per Worker		No. of Workers per Household		Change in Autos Remaining per Household
0.79	−	0.63	x	1.3	=	0.21

Change in Autos Remaining per Household					Base Non-Work VMT		Revised Non-Work VMT
0.21	x	.08	+	1.0	x	33.60	= 34.16

4. CHANGE IN TOTAL HOUSEHOLD VMT FROM BASE

Revised Work Trip VMT		Revised Non-Work VMT		Revised Total VMT
34.14	+	34.16	=	68.30

Base Total VMT: 74.58

Change in Total VMT						% Change in Total VMT
-6.28	÷	74.58	x	100	=	-8.42

POLICY: CP & VP, Employer Financial Incentives

Population Subgroup	AVERAGE HOUSEHOLD VMT					Subgroup Fraction of Total Pop.		NORMALIZED HOUSEHOLD VMT				Percent Change in VMT	
	Work Trip VMT		Total VMT					Work Trip VMT		Total VMT			
	Base	Δ	Base	Δ				Base	Δ	Base	Δ	Work	Total
1	40.98	-6.84	74.58	-6.28	X	0.55	=	22.54	-3.76	41.02	-3.45	-16.70	-8.42
2	4.14	+0.59	4.14	+0.59		0.07		0.29	+0.04	0.29	+0.04	+14.25	+14.25
3	18.95	-0.70	44.15	-0.62		0.38		7.20	-0.27	16.78	-0.24	-3.69	-1.40
AVERAGE						$=\sum$ Subgroup	=	30.03	-3.99	58.09	-3.65		

	Average ΔVMT		Average VMT				% ΔVMT
Work Trip :	-3.99	÷	30.03	X	100	=	-13.29
Total :	-3.65	÷	58.09	X	100	=	-6.28

APPENDIX F

CASE STUDIES

CARPOOL MATCHING AND PROMOTIONAL PROGRAMS

Community Wide Ridesharing Program, Tri-Met, Portland, Oregon

The Portland Metropolitan Area Carpool Project was initiated in January 1974, by the Oregon Department of Transportation (ODOT) (Tri-Met, 1976). The program was the first project in the nation authroized under the Emergency Highway Energy Conservation Act of 1974, with funding made available from Federal Aid Urban System Funds. Beginning in 1975, the project was administered by Tri-Met (Tri-County Metropolitan Transportation District of Oregon) and broadened its scope of services to include not only carpooling but buspooling, vanpooling, fixed route transit, transit incentives, parking management, special services for the handicapped, park and ride lots, and preferential facilities for high occupancy vehicles. The placement of the carpooling project in Tri-Met enabled the program to become more effective by offering, in one package, a wide range of commuting options and incentives for employers and commuters to choose from. The consolidation also resulted in a better utilization of project staff and resources since the carpool project combined efforts with Tri-Met and drew upon their larger and more specialized staff. Finally, Tri-Met's broad political and geographical boundaries encompass the majority of Portland's commuter shed and eliminated potential political conflicts in defining its service area.

The primary methods of reaching commuters with ridesharing information is through employer surveys and a community wide advertising and information program. Employers are contracted and a wide variety of ridesharing options presented. By offering a package of alternatives,

employers are able to select programs and incentives best suited for their organization and level of commitment they desire to make toward employee transportation. This approach also enables employees to inquire about transit and ridesharing information from a central source rather than several agencies. In May 1978, over 1,150 employers and organizations had been contacted and exposed to the ridesharing program. Through these contacts and area wide marketing, the ridesharing and transit incentive programs have contributed the following results as of May 1978: opening of 73 park and ride lots; development of nine express bus routes; 30 employer transit subsidy programs; 19 transit pass and ticket outlets; 65 employer information programs; 61 donated bus shelters; three employers organizing vanpools; 31 employers providing preferential parking for commuters; 500 downtown carpool parking permits sold monthly; and 12 carpool information signs along Portland streets, (Tri-Met, 1979). These results indicate that Tri-Met has been effective in increasing transit usage and ridesharing activities. The coordination of area wide transportation services and an aggressive public information and education program have lead to this high level of awareness and acceptance by Portland commuters.

Community Wide Ridesharing Program, Knoxville Commuter Pool, Knoxville, TN

The Knoxville Commuter Pool (KCP) initiated operations in January 1976, as a Service and Methods Demonstration Program funded by the Urban Mass Transportation Administration. The program was administered by The University of Tennessee's Transportation Research Center for the first 18 months of operation as a third party contractor to the City of

Knoxville. In July 1977, KCP became a part of the City's Department of Public Transportation Services where it remained through December 1978, the end of the UMTA demonstration grant period. Currently, it is once again operating within The University of Tennessee's Transportation Research Center under a State Energy Commission grant. Even though KCP operated as part of Knoxville City Government, it focused its program throughout the entire Knoxville standard metropolitan statistical area.

During the first 18 months of operation, the primary efforts of KCP were three fold; implementation of a third party vanpool program involving 51 vans, development of a community wide ridesharing program involving computerized matching of potential carpool and vanpool riders, and elimination of institutional barriers such as regulatory controls and insurance coverage. In conjunction with the move to the city, KCP broadened its scope of operation to include assistance to social service agencies, transit information, downtown fare free transit zone, and employer incentives to ridesharing.

The project staff was quite large during the first 18 months at the University and reflected the demonstration nature of the project. Staff was reduced to six full-time and three part-time persons while at the city and currently the program operates with a full-time staff of four and four part-time employees.

The primary method of solicating commuter participation was through extensive personal contact with employers by KCP field representatives and a community wide advertising and public information program. These methods proved to be the most effective and inexpensive means of directly reaching large numbers of commuters with ridesharing

information. KCP attempted to establish an ongoing working relationship with each firm through a company coordinator who developed ridesharing efforts within their firm. The relative success of the ridesharing program within each organization was generally a function of the coordinator's interest, and the degree of importance placed upon their ridesharing duties. As of June 1980, KCP has contacted more than 829 employees with approximately 360 participating in the program. In conjunction with employer contacts, a community wide advertising and public information program is being conducted to encourage commuters to call KCP for ridesharing information. Currently there are approximately 19,500 commuters on computer file available for ridesharing matching purposes. The Knoxville Commuter Pool has not had great success in increasing the number of commuters carpooling to and from work with the area wide percent remaining relatively stable at about 45 (1.36 vehicle occupancy). It appears that the low level of traffic congestion, availability and low cost of parking, and stable gasoline prices in the Knoxville area have produced little incentive to carpool. The major success experienced by KCP has been the introduction of vanpooling to the community and the establishment of about 75 privately operated vanpools.

In July 1977, with the move to the city, KCP expanded their services to include transit and vanpooling information on commuter match lists. Each commuter requesting a list of fellow commuters interested in ridesharing also receives information related to bus routes (regular or express) and vanpools operating in their area. During the Fall of 1977, KCP also initiated a concentrated campaign to promote ridesharing to central business district employers and employees. A unique feature

of this CBD program is that besides distirbuting match lists to employees, KCP calls potential ridesharers on the telephone and provides the initial introduction to other commuters through a conference call. This method has proven very successful compared to just distributing match lists. Of the 3,279 persons called, 7.4 percent have switched to new ridesharing arrangements, such as carpools, vanpools, or buses.

Based upon a general population attitude survey, the Knoxville Commuter Pool has been well received by commuters with 79 percent favoring the continuation of KCP. The major opposition which severly affect KCP's credibility with employers and caused hesitation in program planning came from political leaders and transit union officials. Elected city officials have been continually concerned with the issue of providing services to noncity residents since the city is the local funding agency. This has resulted in a continuing battle for funding and an uncertainty as to whether KCP would be in existance from year to year. The issue was one of the primary reasons for relocating KCP back to the University. The local transit union also played a role in influencing city officials by suggesting that KCP had the potential to divert a large number of riders from transit and cause the transit deficit to increase. To help overcome this issue, KCP included transit information on computer match lists and as a result of their telephone calling program, placed more commuters into transit than either carpooling or vanpooling. This program has helped to establish a better working relationship between the transit system and KCP.

Community Wide Ridesharing Program, Car Share, Houston, Texas

The Houston Car Share program began operations in March 1975, in an effort to reduce peak period traffic volumes. The

program is funded from Federal Aid Urban Systems funds with the Texas State Department of Highways and Public Transportation providing the local share. Annual project funding in 1975 was about $81,000 and has risen to $160,000 in 1978 and $302,000 in 1979 (Car Share, 1979). The sudden increase in 1979 was primarly the result of an extensive marketing campaign and overall expansion of services. Currently the program is operated by a fulltime staff of 10, an increase of two over 1975 levels. Car Share is currently housed within the Metropolitan Transit Authority of Harris County which was formed in January 1979 and also manages the city's transit system.

Car Share services include not only carpool matching but information and programs on transit services, park and ride lots, vanpooling, preferential travel lanes, and employer incentives for ridesharing and transit. This wide range of alternatives has allowed employers and commuters to choose those options best suited to their needs.

Car Share's contract with commuters is primarily through areawide marketing campaigns and contacting area employers. Since Houston has severe air pollution problems the Environmental Protection Agency has mandated all employers with more than 250 employers to undertake some type of transportation incentives program for their workers. As a result of this mandate, Car Share concentrates their personal employer contact program to these large employers since there is greater incentive for the employer to initiate an incentives program. Smaller employers are usually contacted by mail and telephone. Marketing the program on a community wide basis, Car Share has utilized numerous sources for distributing brochures and matching applications. These

sources include; area banks who distribute brochures to new customers, local libraries, fast food restaurants, and the Girl Scouts through their cookie sale.

Car Share has undertaken an intensive program to stimulate vanpooling in the area and has been instrumental in initiating 39 company vanpool programs comprising over 681 vans. Car Share has also established a joint venture with private enterprise to implement a third party vanpooling program for Greenway Plaza and Post Oak, major Houston activity centers with a work population of 13,000 and 50,000 persons respectively.

In addition to these activities Car Share has been successful in doubling the number of monthly transit passes purchased through employer incentive programs, establishing 21 carpool staging lots in cooperation with area churches and merchants, providing carpool matching to park and ride lots from home residences for express bus riders, and certification of over 160 commuter vans for operation on the North Freeway Contra Flow Lane.

VANPOOL PROGRAMS

Community Wide Vanpool Program, Commuter Computer Vanpool, Inc., Los Angles, California

Commuter Computer Vanpool, Inc. (CCVP) is a private nonprofit corporation that acts as a third party supplier of vanpools (Valk, 1979). Commuter Computer leases vans to area commuters and contracts for administrative and marketing support from Commuter Transportation Services, Inc. (CTS), the regional ridesharing organization. Vehicles are leased from a leasing company and payments guaranteed by two Los Angeles banks in the event of a shortfall of funds. Primary funding support for the program is through the state Energy Commission and California Department of Transportation (CALTRANS).

Vanpools are formed by CTS vanpool matching representatives by calling commuters who have identified themselves as interested candidates for vanpooling. Drivers are found through the same process and when eight committed riders and a driver are identified the vanpool route is established.

The CCVP program began operating in April 1976, with the leasing of 20 vans through Crockerbank Lease plan. The bank agreed to underwrite 100 percent financing of these 20 vans and handle administration and maintenance of the vans. These 20 vans were converted to 10 passenger luxury vans with airline type reclining seats and deluxe interiors. These initial 20 vans were very successful and by January 1980, the program had 135 vans operating. The luxury vans have been very popular with commuters but to increase the market for vanpooling to more price sensitive commuters, other more economical seating arrangements (bench

seating) have been introduced. The average one-way commute distance for vans is 32 miles.

In January 1980, Commuter Computer was designated by CALTRANS to be marketing agent for a newly implemented California Vanpool Program (Schreiber, 1980). This new concept is a partnership between a governmental agency and a subsidiary of the Chrysler Corporation, to make commuter vans available to employers throughout the state. Vans are leased on a month-to-month basis and in just two months 16 vans were placed into service. Turnaround time has been greatly reduced with this plan to 5 to 7 days for individual requests.

Community Wide Vanpool Program, Golden Gate Bridge, San Francisco, California

In September 1977, the Golden Gate Bridge Highway and Transportation District initiated a vanpool program to relieve traffic volumes on the bridge and overcrowding on certain bust routes (Shellenberger, 1979). The project was funded as a Service and Methods Demonstration Project of the Urban Mass Transportation Administration. Under the grant, 35 vans were purchased to introduce the concept of vanpooling to commuters in the corridor. The projects primary goal was to stimulate the operation of owner-operated vanpools by leasing project vans to commuters for a guaranteed six-month time period. During this time operators can establish their pool and if it proves successful, are encouraged to purchase their own van to continue the existing pool. The project van was then released to another commuter and the cycle repeated. The District maintains and insures the project vans and provides assistance on financing, maintenance, and insurance to individuals wishing to purchase their own van.

The first two vans were put into operation at the beginning of October 1977 and seven months later 32 vans were operating. The primary marketing tool for van promotion has been the vans themselves. Project flyers have been distributed to vehicles at the toll gate to the bridge and buses serving Sonoma County commuters, and shopping centers in residential areas. Through April 1979, the vanpool program has resulted in the formation of 15 vanpools who are now utilizing privately owned vans On the average each van has removed six to seven cars from the road.

Community Wide Vanpool Program, State of New Jersey Vanpool Program

The New Jersey Vanpool Program (NJVP) was initiated in late 1975 by the New Jersey State Department of Energy (DOE, 1979). The program primarily involves the development of informational material on vanpooling for employer sponsored programs. The state does not own or lease vans but rather provides the stimulus and operational assistance for starting up and administrating employer sponsored and operator vanpools.

The NJVP has sponsored numberous workshops for employers to introduce them to the concept of vanpooling. These workshops present information on the concept of vanpooling, administrative and operation procedures of implementing a program, and provide a forum for company executives to discuss vanpool issue with managers of existing vanpool operations. Through gathering private sector representives together, program resources are minimized. For those employers most interested in initiating a vanpool program, personal contact and followup promotional activities are undertaken.

Based on the response from the private company sector, promotional activities were initiated with county governments and union groups. The 21 counties in New Jersey are currently being encouraged to develop vanpool programs. Meetings have been held with each of the county planners, assisting them in the development of uniform procedures for obtaining vans via interest free loans that are available from the Federal Highway Administration. County executives are being encouraged to sponsor workshops for local businesses to emphasize the benefits associated with vanpooling. The State Department of Energy plans and conducts these workshops in a small working group atmosphere.

Since many firms have not initiated company sponsored vanpool programs, promotional activities are also being aimed toward union sponsorship/participation. An information manual for unions, emphasizing owner operated arrangements has been distributed to over 1975 locals in New Jersey.

Community Wide Vanpool Program, Knoxville Commuter Pool, Knoxville Tennessee

The Knoxville Commuter Pool (KCP) was initiated by the City of Knoxville in January 1976, as a Service and Methods Demonstration Project of the Urban Mass Transportation Administration. The objective of the project was to establish an organization that would promote the greatest possible utilization of high occupancy transportation vehicles both public and private throughout the metropolitan area. A major aspect of the program was the availability of 51 seed vans to the broker to introduce the concept of "vanpooling" to the public. These vans were provided to demonstrate that individuals could operate their

own successful vanpool with assistance from the broker. The intention of the program was to initially lease the vans to individuals throughout the community and later sell them to these individuals and encourage private ownership of the vehicles or encourage individuals to buy their own van and release KCP vans to someone else. The program has proven successful with 50 of the vans being sold to individuals who are now operating them as private vanpools. The remaining van is used as a backup van where members of the Knoxville Area Vanpool Association can lease the van while their van is being repaired.

As of January 1979, KCP was influenced the formation of approximately 75 vans carrying over 780 passengers. The average one-way commuting distance for KCP vans is 45 miles and the majority of riders, 58 percent being diverted from carpools. On the average each van replaces 5.02 vehicles. The primary incentives for vanpooling are avoiding driving every day and savings in energy and money.

Another feature of KCP was the establishment of the Knoxville Area Vanpool Association (KAVA) in mid 1977. This organization provides members with free administrative services, including utilization of the computer matching system. KAVA members receive discounts ranging from 5 to 20 percent by approximately 50 businesses in the Knoxville area on the purchase of tires, parts, maintenance and other services not only for their vans but for their personal vehicles. Although owners must arrange for their own service and maintenance, KAVA does provide a backup vehicle for members at a fee which covers capital and operating costs for the van while in use. Van financial assistance is available through KAVA efforts in the way of a vanpool abort program which guarantees lending institutions 90 percent of the van purchase price if 100

percent financing is made available to the applicant. Approximately, 50 members have participated in the Abort Program guarantee. KAVA has also established minimum insurance specification, and has agreements with several insurance underwriters for providing coverage.

Employer Based Vanpool Program, Prudential Insurance, Newark, New Jersey

Prudential Insurance initiated their company operated vanpool program in July 1975, with the purchase of a single 12-passenger van (Gray, 1978). Today, the company operates a 108 vehicle vanpool program. The unique feature of the program is that it involves reverse commuting, picking up employees in the City of Newark and transporting them to suburban satellite offices. Besides the commuting trips, vehicles are also used for general company business during the day. This dual vehicle use has resulted in a unique fare structure. At the end of each month, Prudential sends the van driver a bill based on "chargeable miles" (total van mileage minus company business use miles). The driver must pay in five days a charge of 10 cents per mile to cover all fixed and operating costs other than gasoline (gasoline is paid by the pool). It is the responsibility of the driver and riders to determine the amount, method, and time of fare payment to the driver. The program has been received very enthusiastically by employees since its start.

Employer Based Vanpool Program, Tennessee Valley Authority, Knoxville, Tennessee

In 1974 in response to moving into a new twin tower complex and elimination of 1,300 downtown parking spaces, TVA elected to undertake a ridesharing program rather than initiate a massive downtown parking

construction program. As one element of the ridesharing program, TVA initiated a vanpool program in cooperation with the TVA Employees Credit Union. This partnership was necessary since legal restraints prohibited the federal agency from directly administering the program. An agreement was drawn up between TVA and the Credit Union (a private agency) delegating the responsibility for leasing the vans to the Credit Union.

The program began with six 12-passenger vans and has since been expanded to 84 vans at the Authority's downtown Knoxville headquarters. The vans were originally leased from Hertz Rent-A-Car for a period of two years but later a decision was made to purchase the vans because of the significant monetary advantages of purchasing the resale. An important factor in a success of the van program has been the financial incentive paid by TVA to employees who vanpool. Each vanpool rider is credited $3.00 to $11.00 each month (depending on trip length) by TVA, or approximately 35 percent of the fare. Approximately 22 percent of TVA's 4,200 employees commute by vanpool. The average one-way commuting distance for TVA Knoxville vans is 35 miles with the majority of riders, 45 percent, being divereted from single occupant automobiles. On the average each Knoxville van replaces 6.1 vehicles. The primary incentives for vanpooling are reduced parking and commuting costs and avoiding driving every day.

The success of the Knoxville program has lead TVA to initiate vanpool operations at its other offices throughout the Tennessee Valley. TVA also operates vanpool programs at their various nuclear plant construction sites in an effort to ease traffic volumes on access

roads. Currently, TVA operates approximately 170 vans at various construction sites with the Hartsville Nuclear Plant being the largest with about 120 vans.

EMPLOYER FINANCIAL INCENTIVES FOR CARPOOLS AND VANPOOLS

Employer Financial Incentives, Port of Portland, Portland, Oregon

The Port of Portland initiated a variety of incentives for encouraging carpool and transit usage by its 300 employees in December 1973. For carpools of three or four passengers, the Port contributes $10.00 toward the monthly parking fee and for carpools of five or more, it contributes the $10.00 parking fee plus 11 cents per mile of the round trip commuting distance. Transit users are reimbursed up to 70 cents per day for bus fares.

Approximately 25 percent of the work force are taking advantage of these incentives. Some controversy and criticism has envolved over the use of public funds to subsidize communting costs.

Employer Financial Incentives, Tennessee Valley Authority, Knoxville, Tennessee

In response to moving into a new twin-tower complex and elimination of 1300 downtown parking spaces, TVA elected to under take a ridesharing program rather than initiate a massive downtown parking contruction program. A major element of this program was a commuter reimbursement program for its 4,200 employees. Starting in January 1975, TVA employees were reimbursed for travel by bus (express or regular fixed-route), vanpools and carpools with three or more passengers. Bus riders are reimbursed for one-third of the cost of the commuter bus ticket, carpoolers were issued a $5.00 monthly municipal parking ticket and vanpoolers are credited three to eleven dollars per month. This reimbursement program is still in effect today, except for the carpool parking ticket which was discontinued because of the remoteness of the parking garage and enforcement problems.

Since the reimbursement program has been in effect, the percent of TVA employees ridesharing has grown from 34 percent to 85 percent. Currently, 26 percent commute by bus, 37 percent carpool and 22 percent vanpool. In addition to the reimbursement program, TVA also established a company sponsored vanpool program which currently operates 84 vans at the Knoxville headquarters.

The incentive program has been a major factor in the decision to rideshare by employees and was demonstrated when the reimbursement program was discontinued during labor negotiations for two months, bus and vanpool ridership dropped by half. The reimbursement program was a major bargaining item in recent labor negotiations and considered very favorably by most employees.

Employer Financial Incentives, United Gas Pipe Line Company, Houston, Texas

United Gas Pipe Line Company (UGPL) initiated an incentive program in May 1975, which reimburses employees for either carpool parking or transit fares. Employees riding transit are given the option of either receiving a free $18.75 monthly bus pass that can be used on all HouTran services or be reimbursed up to 90 cents per day for transit fares. Carpools with four or more occupants receive free parking in the building garage, three person carpools are reimbursed two-thirds their parking cost up to a maximum of $55 per month, and two person carpools receive one-third their parking cost up to the same maximum limit. All riders in each carpool must be an employee of UGPL to qualify for a reimbursement. Monthly parking rates are currently $70 per month in the building

gargae and monthly bus passes are purchased in bulk by UGPL at a 25 percent discount. The program was initiated in an effort to improve employee morale since the company had just relocated its office in downtown Houston from a small town in Louisiana.

During the first year, 74 percent of the 685 employees participated in the program. Currently, UGPL employs 1,010 persons with 69 percent taking advantage of the subsidy program; 367 receive monthly bus passes; 37 participate in the daily transit subsity; 233 ride in four person carpools; 15 in three person carpools; and 26 in two person carpools. The program has been well received by employees and there are no plans to discontinue the program.

Employer Financial Incentives, Tenneco, Houston, Texas

In 1977, Tenneco located in the heart of downtown Houston, Texas, initiated a carpool and transit incentive porgram for its 2,000 employees. The company leased a parking lot which was made available at no charge to employees carpooling with two or more Tenneco employees. This amounted to a monthly subsidization of $45 for each carpool. The lot is presently filled to its 150 car capacity and accommodates approximately 425 Tenneco employees. Tenneco also offers HouTran bus passes for its employees at no charge. These passes are purchased by Tenneco at a 25 percent discount from HouTran and can be used on the Mini Bus system, Park and Ride express service and any regular HouTran route.

PREFERENTIAL TRAFFIC CONTROL

Freeway Ramp Bypasses, Los Angeles, California

Preferential freeway access is given to buses, vanpools, and carpools with two more occupants at over 90 metered freeway on-ramps in the Los Angeles area (Goodell, 1974; California DOT, 1979). These bypass ramps generally have two lanes approaching the metering signal and then narrow to one lane downstream of the signal before merging with the freeway. The bypass lane is usually the far left lane so that queues of regular traffic will not block the bypass lane entrance. The bypass lanes were first introduced in June 1973, and April 1974, at two locations and by October 1975, 13 bypasses were in operation. Currently, there are over 90 ramps in operation and plans for additional bypasses.

The initial two bypass ramps resulted in the number of carpools increasing by 180 percent and saved each carpool approximately five minutes in travel time. About half of this increase was through new pooling arrangements while the other half was attributed to diversion of carpools from neighboring ramps and surface streets.

Results from all 13 initial ramps showed an average increase of 50 percent in the number of carpools using the bypass ramps since they were installed. From a survey of 77 bypass lanes, about 40,000 commuters take advantage of the bypass lane savings each day. Thirty-one thousand are riding in multi-occupancy vehicles and 9,000 are riding in buses. The increase of multi-occupancy vehicles using bypass lane ramps after they are installed is now an average of 25 percent for all ramps surveyed. Travel time savings average one and one-half minutes for each commuter.

Violation rates range from 10 to 56 percent with an average of 30 percent. Preferential ramp bypasses have been well received by all freeway users, primarily because nonusers perceive no delay or added congestion as a result of their presence.

Ramp Bypass for Carpools, Minneapolis, Minnesota

As part of the I-35 Urban Corridor Demonstration project, a carpool bypass lane was constructed in conjunction with nine bypass ramps for buses at metered freeway entrances (Benke, 1976). The Grant Street project permits carpools with three or more occupants to share the use of the ramp with buses. The bypass ramp is located in downtown Minneapolis and serves much of the CBD. Its use by carpools is limited to the evening rush peak period and was initiated on November 18, 1975.

After six months of operation, approximately 70 carpools use the bypass lane during the three hour evening peak period. Usage has been below estimated demand and can be related to the small savings in travel time gained by using the bypass ramp. In general, delays at metered ramps are less than two minutes which produces little incentive to form a carpool. Violation rates have ranged between 6 and 20 percent depending on the level of enforcement.

Cherry-Columbia Bypass Ramp (I-5) for Ridesharers, Seattle, Washington

On March 3, 1977, an exclusive reversible bus ramp leading into a special downtown circulation loop was opened to carpools with three or more occupants. Initial projections were that 100 carpools would

use the bypass but after 12 months, over 150 carpools are using the ramp during peak hour with no delay to buses. Users experience a travel time savings of 5 to 10 minutes.

Preferential Lane on Arterial South Dixie Highway, Miami, Florida

The South Dixie Highway is the main route connecting downtown Miami and the Central Miami area with the suburban southwestern section of Dade County (Public Technology, 1977; Rothenberg, 1977). The highway is a six lane divided arterial with heavy commercial strip development on both sides and multiple cross streets and access points. The length of the corridor is approximately 18 miles and currently average daily traffic is 60,000 vehicles.

The South Dixie Highway Demonstration Project originally featured three major components: (1) a contra-flow bus lane; (2) a concurrent-flow carpool lane (2 or more occupants); and (3) traffic signal improvements giving increased "green time" to through traffic on the entire corridor. The preferential lanes both contra-flow and concurrent-flow, extend 5.5 miles from the CBD and were opened on July 22, 1974. The lanes are in effect from 7 to 9 a.m. and 4 to 6 p.m. on weekdays. Left turns are prohibited from the highway during these hours with cross-highway movements being accommodated through a series of right turn ground loops marked by signs. The contra-flow lane which is reserved for bus use only, is located in the median lane of the off peak direction and is separated from opposing vehicles by removable safety posts. Notice of these lane configuration changes is provided by overhead variable message signs in the normal traffic direction. The concurrent-flow lane is reserved for carpools of two or more occupants and is

located in the median lane of the peak period direction. Initially the carpool lane was separated by safety posts but problems of vehicles attempting to enter or exit the lane, as well as maintenance costs, forced the elimination of this feature.

In addition to these operational improvements, four park and ride lots were established in sections of suburban shopping center lots along the corridor. A 200 car lot was constructed a short distance from the southern terminus of the lanes in a fairly dense area of apartment buildings (Dadeland). Parking is free and the lot is filled to capacity daily by most transit riders.

Capital cost for the project totaled $626,181 with the following breakdown: parking lot improvements $116,000; signs and removable posts $270,281; installation of bus shelters and signs $60,800; signal attenuators $60,000. Annual operating cost was approximately $1,354,760 with the following breakdown: police enforcement $65,000; placing of posts and shelter maintenance $275,000; transit operations (deficit) $917,260; administration $58,650; and marketing $38,850.

At the beginning of the project, five new transit routes were added to existing services in the corridor to make a total of 42 runs each morning and afternoon. As ridership patterns changed and unproductive runs were eliminated, service was reduced to 31 morning and 30 afternoon routes. Shelters and schedule information are provided at all park and ride lots and most walkup bus stops along the corridor. An extensive feeder system provides localized pickup service in the market area with all buses passing through the Dadeland park and ride

lot before entering the contra-flow lane. The oneway fare is 50 or 60 cents depending on the loading point. After one year of service, bus ridership increased from 365 to 2,000 daily riders. Bus travel times have decreased by 50 percent from 18 minutes to 9 minutes.

After one year of operation, the contra-flow lane was eliminated and buses began running in the carpool lane. The major factors in this decision were the high costs of enforcement and safety post placement. Bus travel times increased to approximately 12 minutes and daily patronage dropped from 2,000 to 1,700 riders. Nearly two-thirds of all bus patrons had driven to work by themselves before the project and overall 77 percent had used automobiles for their trips prior to the project. The major reason for riding the bus was convenience with travel time and cost savings being the next most mentioned reasons.

The number of carpools with two or more occupants increased 52 percent after one year of operation from 2,641 to 4,012. The auto occupancy rate has risen from 1.38 to 1.60. Preferential lane travel time decreased six minutes from 18 to 12 minutes while general lane users experienced a one to two minute increase. Since the implementation of the project, the highway now carries 2,400 more persons in 350 fewer autos.

During the peak hour, the preferential lane carries about 40 percent of all persons on the highway. The primary reason for forming a carpool was fuel and travel time savings, while the need for a car during the day was the major reason for not carpooling.

The number of accidents in the initial nine month period of the project increased from 148 in the same nine month period in the preceding

year to 245. Of these accidents, many were rear-end collisions while many of the remainder were small increases in left turn accidents and accidents that involved hitting fixed objects. The rate of bus related accidents initially increased dramatically but leveled off at a rate of about 2 accidents per month. In the opinion of local policy makers, the accident rate has increased but not enough to offset the significant benefits derived from the project.

Violation rates have been extremely low, about six to eight percent, primarily as a result of strong enforcement efforts. A total of six off-duty police officers patrolled the project area during the peak periods and were paid overtime rates as part of the project. Vacant left turn storage bays allowed high visibility of police officers and provided a place to pull over violators.

Preferential Lane on Arterial, Kalanianaole Highway, Honolulu, Hawaii

The Kalanianaole Highway is the major route connecting the eastern portion of Oahu to the University of Hawaii and the Honolulu CBD a distance of approximately 12 miles (Kaku, 1977b). The highway varies in configuration from a four lane undivided arterial to a six lane divided arterial. The preferential lane was first introduced to bus use only on August 21, 1973. The preferential lane operates as a contra-flow lane in the westbound (inbound) direction for 1.9 miles on the four lane undivided section of the highway and .5 miles as a concurrent-flow lane in the six lane divided section. The lane operates only in the inbound direction from 6 a.m. to 8 a.m. The contra-flow lane is established by placing traffic cones and portable traffic signs on the dividing line between the eastbound (outbound) lanes. The

cones and signs are in place only during the period the preferential lane is in operation. Access into and out of the lane is unrestricted on the contra-flow section with left turns being restricted from the lane. At the end of the four lane section, the preferential lane crosses over into the median lane of the six lane section and extends for an additional one-half mile. On September 15, 1975, the preferential lane was opened to carpools with three or more occupants on a 30-day trial basis, and was later extended to permanent status.

Cost of providing the lanes was approximately $340,000 for street widening and some TOPICS improvements and $2,000 for 20 permanent signs. Annual operation and maintenance costs run $36,000 for placement and removal of portable signs and cones and $1,200 for replacing portable traffic control devices.

Express bus service is provided to both the University of Hawaii and the Honolulu CBD by 16 buses. Average bus occupancy has increased eight percent from 39 passengers per bus in February 1974 to 42 passengers per bus in February 1977, while the percent of passenger trips made by bus has decreased five percent from 16 to 11 percent. This decrease was the result of increased passenger trips on the facility and not a decrease in the number of bus passenger trips. Opening of the lane to carpools did not decrease the number of bus passengers. Currently, bus operations carry approximately 660 daily passengers during the school months. Bus ridership drops about 45 percent during the summer due to the absence of school children.

Volume counts taken shortly after the opening of the lane showed about 820 vehicles were using the preferential lane. Since the counts

were taken so shortly after the opening of the lane, these vehicles most likely represent the diversion of pre-existing carpools. Preferential lane volumes increased by 36 percent to 1,120 vehicles after one year of operation and have risen to about 1,200 vehicles in February 1977. Average vehicle occupancy has increased nine percent from pre-project levels of 1.74 to 1.90 in February 1977. Carpool occupancy is greatly affected by the presence of school children and for those carpools with three or more occupants, 84 percent require a child to be classified as a carpool and 64 percent of all carpool passengers were children. Of all trips on the highway, 28 percent are school or school/work combination related. Currently, the preferential lane carries 39 percent of all persons using the highway during the A.M. peak in 20 percent of the vehicles during school months. In the summer the lane carries 16 percent of all people in eight percent of the vehicles. Vehicle volumes have increased during the A.M. peak period by 22 percent from 3,850 in February 1974 to 4,730 in February 1977, while person trips increased 26 percent from 8,900 to 10,070 during the same time period.

The preferential lane has resulted in travel time savings of 1.9 minutes over pre-project conditions for regular lane users and 3.9 minutes for preferential lane users during school months. In the summer, travel time savings are reduced due to the decrease in vehicle volumes and preferential lane users save less than one minute over regular lane users.

Accident rates have increased only slightly since the initiation of the preferential lane from 2.03 to 2.23 accidents per million miles.

Of the accidents which did occur in the preferential lane, a somewhat larger percentage involved injuries as compared to accidents for the entire facility. Higher speeds in the preferential lane may be the causative factor for this occurence. Violation rates have been extremely low, running below 10 percent.

Initially, the idea of allowing carpools on the contra-flow section drew criticism from local officials due to potential accident conflict but with its continued operation and lack of accidents has been strongly supported by officials. From a survey of users, 90 percent indicated that the lane has made traffic conditions somewhat better on the highway. The primary reason cited for carpooling was the time savings while the need of a car at work was the primary reason for not carpooling.

Preferential Lane on Freeway, San Bernardino Freeway Los Angeles, California

The San Bernardino Express Busway is an 11 mile exclusive roadway for buses and carpools of three or more rides, connecting the City of El Monte to downtown Los Angeles (Crain, 1978). Portions of the busway were open to bus use only in February, 1973 with opening of the entire busway in May, 1974. Beginning in October 1976, carpools of three or more riders were permitted use of the busway from 6 to 10 a.m. and 3 to 7 p.m. This mixed-mode phase was done in two stages, with carpools permitted on only the eastern portion initially and on the whole length of the busway seven months later.

The two unidirectional busway lanes are built in the median strip or alongside the freeway, and are separated from the regular automobile

traffic lanes by either concrete barriers or a buffer lane with flexible posts. The western segment of the busway is a physically separate roadway, with access only at the end points. The easterly segment is in the median of the freeway and is separated by a "buffer shoulder" with flexible posts. A 1,400 space park and ride lot in El Monte with Feeder bus service, operates as the focal collection point for bus riders and ridesharers. On line stations are located at two intermediate points, and two additional access ramps are provided for high occupancy vehicles along the busway. At the end of the busway, buses may enter a 1.5 mile contraflow bus lane that continues into downtown Los Angeles.

In the period that the busway has been in operation, there has been a substantial increase in travel demand in the corridor. This was caused primarily by population growth in the eastern end of the corridor, and also by latent demand being generated as new capacity was added. During bus only operations, bus ridership grew steadily over the first 29 months of operation, from 1,000 to 17,300 daily passenger trips. Ridership has stabilized since the addition of mixed-mode operations at about 18,000 daily passenger trips. During bus only operations, 50 percent of the bus riders formerly drove alone while 25 percent were diverted from carpools. Only 11 percent of these riders were transit captives; while the remaining 89 percent had a vehicle available to them. The market share for transit in the corridor has stabilized near 25 percent of those trips served by the busway. The principal reasons cited for chosing to ride a busway bus were time and cost savings, and freedom from traffic congestion.

The number of carpools utilizing the freeway has more than doubled since mixed-mode operations were initiated, resulting in an increase of at least 800 carpools. These carpools were newly formed and not a result of diversion from parallel roadways.

Carpool volumes have showed a slow, steady growth from about 600 to over 1,400 cars in each four hour a.m. and p.m. peak period. Vehicle occupancy of carpools is 3.3 persons which converts to over 4,600 daily carpoolers. Reverse direction carpool volumes on the busway are negligible, because of its normally uncongested flow. Bus ridership has not been noticeably affected by the introduction of carpools. After a major fare increase in July 1977, roughly 1,000 bus riders switched from buses to carpools and single occupant autos. However, by May 1978, bus ridership appeared to have regained its previous levels.

During each four hour a.m. and p.m. period, the busway carries about 1,600 vehicles containing about 10,000 persons. Total person volume over each four hour period slightly exceeds the average volume on one adjacent freeway lane. The busway showed a sharp one hour peak while freeway lane demand was at capacity over most of the four hour period. During this one hour peak, the busway carries about twice the person volume of one freeway lane. Even with this volume, the busway was operating at only two-thirds of the estimated capacity of 1,200 vehicles per hour.

Travel times for buses have been only slightly affected by introducing carpools, and have remained at about 14 minutes for the 11 mile length (including two station stops). Carpool travel time is approximately 12 minutes on the busway. At the same time, travel time has

grown worse on regular freeway lanes because of congestion caused by merging at the ends of the busway and increased demand.

Carpoolers using this busway can save up to 18 minutes in the a.m. peak and up to eight minutes in the p.m. peak. Busway users also experience a greater degree of reliability in their travel schedule. Over half of the carpoolers surveyed said that they would not be carpooling if the busway had not been opened to carpools. Consequently, 2,600 people are now carpooling as a direct result of mixed-mode operations. More than one-third of busway carpoolers formerly drove alone, one-fourth from buses, and a lesser percentage came from another carpool. Two-thirds of all carpool riders are coworkers and the turnover rate among carpoolers is estimated to be about 25 percent per year. More than half of the carpoolers cited cost related reasons for carpooling, with time savings or convenience reasons being cited next most frequently. Solo drivers cited irregular work hours, need for car during the day, and convenience as major reasons for not ridesharing. Their reasons for not riding a bus were time savings, convenience, and need for a car.

During bus only operations, there were no accidents, violations, or enforcement problems on any part of the busway. During mixed-mode operations, the same thing held true on the physically separated western segment. However, on the eastern segment there was a low occupancy violation rate (less than 10 percent), and a safety problem caused by illegal weaving across the buffer shoulder. This produced an overall accident rate that was about the same as a typical freeway.

Public opinion toward the project has remained strongly positive at all levels. Noncarpoolers felt that the busway should be open to

both buses and carpools, and "the busway was a good investment of taxpayer's money." Since the busway was formed with the addition of another lane rathen than taking away an existing lane, regular freeway users were not affected by the busway and their travel conditions remained unchanged. Accident potential was also eliminated or reduced on the busway through the use of physical barriers or a buffer lane with flexible posts. These two conditions are the primary reason for the favorable public opinion and success of the project in comparison to that of the San Monica Diamond Lane project.

Preferential Lane on Freeways, Santa Monica Freeway, Los Angeles, California

The freeway connects the city of Santa Monica and downtown Los Angeles and is served by a variety of sophisticated traffic control devices, including metered on-ramps with preferential entry at selected locations, a computerized surveillance system, and centrally controlled electronic displays (Billheimer, 1977). The project area is approximately 100 square miles with a 1970 population of 560,000 persons. The average density is 5,640 persons per square mile, but reaches as high as 10,600 persons per square mile in the city of Santa Monica. Land uses are predominantly residential - both single and multi-family with extensive high rise development being constructed in recent years. Considerable land area is in commercial and industrial uses. The residents of the area in general are of above average income. A substantial proportion of them work in the area itself, with approximately 12,300 daily work trips being made to the Los Angeles CBD. Average daily traffic on the

Santa Monica Freeway in the spring of 1975 ranged from 100,000 vehicles at its western end to 240,000 vehicles at the Harbor Freeway in downtown Los Angeles. About 82 percent of the automobiles using the freeway carried a single occupant with only three percent carrying three or more occupants.

On March 15, 1976, the California Department of Transportation implemented a concurrent flow preferential lane utilizing the existing median lane in each direction of a 12.6 mile, eight lane segment of the Santa Monica Freeway for exclusive use of buses and carpools carrying three or more occupants. The reserved lanes referred locally as the "Diamond Lanes", operated in each direction during the peak hours of traffic flow (6:30 to 9:30 a.m. and 3 to 7 p.m. Monday through Friday). No barriers separated these lanes from remaining traffic flow. The diamond lanes were implemented in conjunction with the introduction of a variety of express bus services and opening of three new park and ride lots in western Los Angeles.

This project was the first time preferential lanes had been created by taking busy freeway lanes out of existing service and dedicating them to the exclusive use of high occupancy vehicles. The diamond lanes generated considerable emotional reaction among freeway drivers and other residents of Los Angeles. The opening day events that caused such adverse reaction included bumper-to-bumper traffic, long queues at on-ramps, a malfunctioning ramp meter, many accidents, poor press notices, and critical news commentary. The preferential lanes operated amid much controversy for 21 weeks until August 1976, when a Federal

court order suspended operations for failure to follow correct environmental assessment procedures.

Total project cost was $3,108,000 with the following break down in expenditures; park and ride lots (3) $199,000; signing and pavement markings $163,000; marketing $358,000; evaluation $1,232,000; bus operations (operating deficit for 22 weeks) $886,000; local agency administration $193,000; and court costs $77,000.

During the demonstration travel speeds decreased considerably as a result of the diamong lanes and the difference in speeds between the preferential lane and regular lanes was substantial and attributed to many accidents. Travel times increased up to six minutes in the morning and seven minutes in the evening for nonpreferential lane users. High occupancy users experienced decreases in travel time with greater time savings resulting from priority ramp entrances then the diamond lanes themselves. This is attributed to the added time for weaving through the slower moving regular lanes of traffic to enter and exit the preferential lane.

As a result of the increased travel time and congestion for regular lane users, many commuters switched to alternative surface street routes which caused the number of vehicles and people using the Freeway to decrease. By the last seven weeks of the demonstration, the Freeway carried an average of 1.8 percent fewer people in 10.1 percent fewer vehicles in the peak directions of travel. The number of carpools carrying three or more passengers on the freeway increased significantly, rising 65 percent above pre-project levels by the last 7 weeks of the project (from 3,479 to 5,749 carpools). When the preferential lanes

were dropped, the number of carpools decreased to five percent above pre-project levels, suggesting that the lanes were a primary incentive to ridesharing. A survey of carpoolers sited 65 percent as saying saving money was the primary reason for carpooling. The same survey revealed that 25 percent of the carpools were initially formed during the demonstration period and only 30 percent of the carpoolers identified the lanes as the primary incentive. Commuter Computer, the local carpool matching program, assisted individuals in trying to form pools but evaluation results estimate that it was responsible for the formation of only 193 carpools.

Bus service during the demonstration period was provided by two operations: The Southern California Rapid Transit District (SCRTD), and the Santa Monica Municipal Bus Lines (SMMBL). At the start of the project four new feeder/express routes were added to the existing four routes along with three new park and ride routes. Bus ridership increased from 1,171 riders per day prior to the project to 3,793 rides per day during the last week. At the close of the project, the eight feeder/express routes carried nearly 30 percent of the CBD-destined trips projected to be within walking distance of a bus line. The three new park and ride routes, however, fell far short of expectations and were all discontinued by September 1, 1976. However, two of these park and ride lots remained in operation with the third being closed down during the project. After the close of the demonstration and a five week SCRTD bus strike, ridership on freeway routes still remaining in service was 17 percent below the peak attained during diamond lane operations. Since ridership levels did approach those during diamond

lane operations, it appears that improvements in bus system coverage and service frequency were responsible for the bulk of the observed patronage increases. Average occupancy on SMMBL was 41.1 riders per trip an occupancy rate of 28 percent while SCRTD average occupancy was 19.2 riders per trip, a 38 percent occupancy rate. These low occupancy levels can be attributed to the policy decision of providing as much service as possible early in the project to maximize the possibility of attracting ridership. The average fare paid by riders prior to a fare increase in July and August 1976 was 41.3 cents per ride and after the increase it rose to 61.3 cents per ride. This fare increase seemed to have little impact on the demand for service. Average operating cost per rider over the length of the project was $3.49 for SCRTD and $1.52 for SMMDL. As the project continued, SCRTD costs per rider declined from $4.00 to $2.50 as unproductive runs were eliminated.

The number of accidetns during the demonstration averaged 25 per week, roughly 2.5 times the pre-project average. Expressed in terms of accidents per million vehicle miles (accidents/MVM) the overall accident rate was 5.1 accidents/MVM, falling to 3.7 accidents/MVM during the last month of the project. This closing rate was 2.6 times the rate of 1.40 accidents/MVM experienced during the same period in 1975. The single factor that appears to account for the greatest share of accidents is the pronounced speed differential between the free-flowing traffic in the sparsely occupied diamond lane and the stop-and-go traffic in the congested adjacent lanes, coupled with the frequent weaving due to the variety of possible origins and destinations along the length of the project. Surface street accidents on routes paralleling

the freeway for the first four months of the project increased by 8.8 percent over the four month period prior to the project, and increased by 5.2 percent over the average level experienced in a similar time period during the five years preceeding 1976. Violations fluctuated between 10 and 20 percent of legal diamond lane users with an average of 151 warnings and citations issued daily.

The diamond lane project succeeded to some degree in attracting riders to carpools and transit. However, the project brought about a significant increase in accidents and nondiamond lane users lost far more travel time than carpoolers gained. Consequently, heated public outcry resulted which eventually led to the termination of the project. Removing lanes from an already congested facility contributed heavily to a worsing in congestion and increased travel times and appears to have been one of the chief sources of public dissatisfaction with the project. The scattering of trip origins and destinations throughout Los Angeles, and relatively few users destined for the CBD made carpool formation difficult and decreased the number of potential riders for CBD directed bus services. This scattering also meant drivers would need to enter and leave the diamond lanes at points all along its 12.5 mile length and greatly increased the possibility of accidents. This in turn made freeway operations less safe than it might have been if all drivers had exited a few common destinations with provisions for safe merging. Placing barriers between the preferential lane and the congested adjacent lanes would eliminate this accident potential but at the same time would have dcreased the useability of the diamond lane because of the restricted access/egress points.

Preferential Lane on Freeways, Marin County Route 101, San Francisco, California

In September 1973 a four mile contra-flow bus lane was installed along Route 101 north of San Francisco, in Marin County (California DOT, 1979; Newman, 1976). It extends just north of the Golden Gate Bridge to just south of the Richardson Bay Bridge and is used during afternoon peak period. In December 1974, the preferential lane was extended by crossing over the median and continuing as a concurrent-flow lane for an additional 3.8 miles. A concurrent-flow preferential lane was also added for morning peak periods in the southbound direction for this same 3.8 mile duration. The southbound lanes operate from 6 a.m. to 9 a.m., and northbound between 4 p.m. and 7 p.m. At all other times, these lanes are opened to mixed traffic.

During contra-flow operations, two of four southbound bus lanes are coned off - one for the northbound bus lane and one for a buffer lane. The primary delineation along the lane is plastic stanchions placed at 50 feet intervals. The lane is restricted to buses with a permit thus assuring that those who use the lane are capable and aware of the rules of operation. Set up of the lane begins about 2 p.m. and is finished about 8 p.m. This operation costs approximately $5,000 per month. The capital outlay for implementation of both sections of bus lane was approximately $25,000 for signing and marking.

The concurrent-flow lanes were restricted to bus only use until June 1976 when pressure to open the lanes to carpools came about due to a transit strike. A no-fare policy for carpools on the Golden Gate Bridge was also instituted at this time. The priority lanes provide a

two to five minute time savings, and reliability of travel time was also improved. On the contra-flow lane, buses do not normally save time relative to autos but do enjoy better schedule reliability.

There are approximately 150 buses using the facility during each peak period and slightly over 400 carpools. Carpools use in the corridor has increased, but determining the increase resulting from the priority lanes is not available because of the transit strike and the no-fare policy for carpools at the Golden Gate Bridge. There have been no accidents involving buses and total accidents have remained comparable to the pre-lane conditions. Violation rates range between 10 and 20 percent.

Preferential Lane on Freeway, Interstate 95, Miami, Florida

Interstate 95 is the primarily commuter route, connecting residential areas in north Dade and South Broward Counties with four main service areas, the Miami Central Business District, the Civic Center area, NW 36th street employment area, and Miami International Airport (Wattleworth, 1978; Florida DOT, 1977). The corridor is about ten miles long and has a population density of 3,080 persons per square mile. The freeway varies in configuration from six lanes at the northern section to 10 lanes south of the Airport expressway and carries 170,000 daily vehicles. The preferential lanes were first introduced for bus use only on March 15, 1975, carpools with three or more occupants were allowed on the outbound lane July 14, 1975 and in both directions on December 2, 1975. On January 1, 1977 the carpool occupancy restriction was lowered to two occupants to increase lane usage.

The preferential lanes were accommodated by adding a median lane in the six and eight lane segments of the freeway and designating the far left lane as the preferential lane in the 10 lane segment. The preferential lanes are approximately 7.3 miles in length and are reserved for buses and carpools from 7 a.m. to 9 a.m. southbound and 4 p.m. to 6 p.m. northbound on weekdays with access into and out of the lanes unrestricted. Lanes are open to general use at other times. A 1,320 space park and ride lot (Golden Glades Terminal) with feeder bus service is located at the northern end of the project and is directly connected to the lanes by a flyover ramp.

Total cost of the project was approximately $21 million with the following breakdown of expenditures: lane construction $11.66 million, parking lot $1.71 million; flyover to parking lot $2.98 million; plann--ing and design $2.37 million, signing $1.63 million; buses $1.03 million; and marketing $84,000. Operating costs for one year have averaged about $317,000 with $211,000 being spent for bus operations (deficit), $88,000 for roadway and signing maintenance, and $18,000 for park and ride lot maintenance and security.

Express bus service with no intermediate stops is provided to each of the four major destinations from Golden Glades Terminal. The cost of providing express service is $1.70 per trip with passenger fares covering 60 cents of the cost. A total of 52 buses carrying 1,700 daily passengers use the preferential lanes. Prior to opening of the preferential lanes, buses used NW 7th Avenue a parallel route which was equipped with bus preemption for priority movement at signalized intersections. Daily ridership had grown to 1,100 passengers when operations

were moved to I-95, and increased to 1,600 daily riders during three person carpools. Reducing the minimum carpool occupancy requirement to two persons has not reduced bus ridership. Travel times for buses also improved considerably when operations were moved to I-95. The reduction in carpool occupancy had no affect on a.m. bus travel time, but did increase p.m. travel time to that of regular lane users during the peak hour of the p.m. peak period. This increased travel time was primarily caused by a high violation rate (32 percent) in the preferential lane.

The number of carpools with three or more occupants increased 74 percent with the introduction of the preferential lane from 390 to 680. Reducing the occupancy increased the number of carpools using the lanes but reduced the number of carpools with three or more occupants to 590. The number of persons carried by the preferential lane increased almost 200 percent over the three person minimum from 3,278 to 9,772 persons. During the three person phase, the lanes carried 7.3 percent of all persons using the freeway in 4.7 percent of all vehicles and presently 20.4 percent of all persons are carried in 16.0 percent of all vehicles. Vehicle occupancy on the entire freeway has increased from pre-project conditions of 1.31 persons per vehicle to 1.32 during three person carpools and 1.38 for two person carpools. Since the initiation of the lanes person volume on the entire freeway has increased by 28 percent while the number of vehilces has increased by only 20 percent. Carpool users in the preferential lanes experienced a decrease in travel time of 5.5 minutes from 13 to 8 minutes during three person carpools. Lowering the occupancy rate caused no changes in a.m. travel time for preferential lane users and increased just slightly p.m. travel time.

Travel time in the general lanes decreased 2.3 minutes for the three person phase and an additional 1.7 minutes during two person carpools. Carpoolers indicated that their primary reason for carpooling was cost savings rather than travel time savings.

The number of accidents increased during the three person phase from an average of .797 accidents per day to .858 accidents per day and decreased with two person carpools to .611 accidents per day. The lower accident rate is attributed to easier weaving movements into and out of the preferential lanes because a greater percentage of vehicles were now traveling in the lanes. Violation rates were extremely high during the three person carpool phase and ranged between 50 and 75 percent. This high violation rate and the underutilization of the lanes were major reasons for decreasing the carpool occupancy rate. As expected the accident rate decreased to 37 percent with two person carpools but was still above acceptable levels. A major cause of the high violation rate was the lack of adequate facilities to pull violations over in the median area and the difficulty in moving vehicles over three and four lanes of traffic.

The preferential lanes have been received favorably by commuters even during the three person carpool phase. The decision to lower the occupancy requirement was initiated through public response to the underutilization of the lanes, but at the same time the public still viewed the lanes as being desirable. The acceptance of the project to general lane users is attributed to the uninterruption of travel in these lanes. Travel time and congestion were not increased through introduction of the reserved lanes because the lanes were added to

existing lanes and where they replaced existing lanes, four other lanes were available for regular users. The preferential lanes reduced the volume on the regular lanes by removing carpool vehicles. The central destination of commuters to the four major employment centers also attributed to reduced congestion and accidents by the absence of a large amount of weaving. The ability to form new carpools has not been extremely successful and may be related to the lack of a carpool matching and promotion program in the Miami area.

Preferential Lane on Freeway, Moanalua Freeway, Honolulu

The Moanalua Freeway is the major commuter route to central Honolulu from Leeward and Central Oahu. The corridor has recently been upgraded from a four lane arterial to six lane freeway standards (plus climbing lanes on uphill sections) for a 3.5 mile section (Kaku, 1977a). The roadway currently carries approximately 100,000 daily vehicles. The preferential lane for buses and carpools with three or more occupants is located in the median lane in each direction of the new freeway section, with access being unrestricted. The eastbound (inbound) lane is 2.66 miles while the westbound (outbound) lane is 1.33 miles. The lane is reserved 24 hours a day seven days a week. The lanes were opened to traffic in both directions on January 7, 1975 in conjunction with the opening of the entire freeway section. Consequently the lanes were never available to regular lane users and no reduction in capacity was imposed. The actual cost of the preferential lanes cannot be directly determined since they were constructed in conjunction with the overall upgrading of the facility but costs for preferential signing and pavement markings were approximately $10,000.

Bus service has remained constant since the introduction of the lanes with no new services being added. Ridership levels have remained high with an average bus occupancy of 50 persons in six buses. Evaluation results of the preferential lanes on carpool formation were gathered only in the a.m. peak period from 6 a.m. to 8 a.m. since the facility is operating at peak capacity during this time. Evaluation efforts were not undertaken in the p.m. peak since traffic volumes are less than available capacity causing no congestion or significant travel time savings to high occupancy users.

The average vehicle occupancy has increased on the entire freeway facility by 14.7 percent from 1.70 persons per vehicle prior to the project to 1.95 persons per vehicle in February 1977. During the morning peak, two hour period, carpool use has increased from roughly 500 vehicles to approximately 1,500 carpools carrying a total of about 5,100 persons. The percentage of passengers in carpools of three or more persons increased from 32 to 51. A unique aspect of the facility was the number of school children which are passengers in carpools. Approximately 20 percent of all trip purposes of the facility are either school or work/school combination trips. Of those carpools with three or more passengers, 61 percent need children to qualify for the preferential lane and 47 percent of all persons carpooling were children. During the summer months when school was not in session, carpool occupancy drops to 1.66 passengers per vehicle. Total vehicle volume is only slightly lower in the summer, but total person volume is down almost 20 percent as a result of the absence of school trips. During school months the preferential lane carried 45.2 percent of all people

using the freeway in 26.2 percent of the vehilces while in the summer, 38.4 percent of all people are carried in 20.6 percent of the vehicles. Since the opening of the lanes approximately the same person volume was being served in 11 percent fewer vehicles. Preferential lane users on the average save 3.6 minutes in travel time over regular lane users when school is in session and 6 minutes during the summer. This travel time savings was the primary incentive expressed by carpoolers while the need for a car at work was the major reason for not carpooling.

The introduction of the preferential lanes has not resulted in an increase in the number of accidents. Even though a comparison cannot be made to before conditions since the freeway facility did not exist, the current accident rate of 2.4 accidents per million vehicle miles is comparable to rates on other similar freeways in the area.

Initially violation rates were 20 percent of vehicles using the preferential lanes but as utilization of the lanes has increased, violations have decreased below 10 percent. The primary reason for the lower violation rate was increased utilization by eligible vehicles and spot enforcement.

The preferential lanes have been well received by commuters in the corridor primarily because of the overall upgrading of the facility and its increased capacity. Regular lane users have not experienced an increase in travel time or congestion as a result of the project. The termination of the preferential lane within the newly constructed freeway section results in a bottleneck during peak period and reduced to some extent the travel time incentive gained by the lane.

Preferential Lane on Freeway, Banfield Freeway, Portland, Oregon

The Banfield Freeway is the primary east-west commuter route between downtown Portland and east Multnomah County (Oregon 1978). The east side project area has a 1975 population of 235,000 and approximately 88,000 employees. The six lane freeway presently carries an average weekday traffic of 112,100 vehicles an increase of 2,100 vehicles over 1975 pre-project conditions. The preferential lanes for buses and carpools of three or more occupants was initiated on December 15, 1975 through addition of a concurrent-flow median lane. The preferential lane was accommodated within existing right-of-way by eliminating the median shoulder and narrowing the existing lanes to 11 and 11.5 feet with the exception of the 12 foot preferential lane. The cost of the addition was $500,000. The preferential lanes extend 3.3 miles in the westbound (inbound a.m. peak period) direction and 1.7 miles in the eastbound (outbound, p.m. peak period) direction and is separated from the regular lanes by only stripping and raised pavement markers. Initially the preferential lanes were reserved for high occupancy vehicles (HOV) on a 24-hour basis but due to underutilization were restricted to HOV's only during peak rush periods of 6:30 to 9:30 a.m. and 3:30 to 6:30 p.m. Monday through Friday.

The preferential lanes are utilized by five express transit routes which originate at several peak and ride lots. There are 58 buses operating in the preferential lane during restricted hours, 28 buses in the morning peak and 30 buses in the evening. Transit ridership has increased from 300 passengers per day in January, 1976 to 633 passengers per day in June, 1977. The majority of bus riders, 47 percent,

were diverted from other nonexpress transit roues while the remaining 43 percent were either automobile drivers or passengers.

The number of carpools with three or more occupants showed a sharp increase shortly after the lane was first introduced from 106 in April, 1975 but gradually leveled off to 518 in June, 1977. The majority of carpool passengers, 53 pecent, were formerly in carpools while 27 percent were diverted from transit and 20 percent drove alone. Carpool passengers indicated that cost savings and convenience were the most important incentives to carpooling. Noncarpoolers expressed that inconvenience and the need for a car at work were their most important reasons for not carpooling.

Vehicle occupancy has increased only slightly from 1.224 persons per vehicle to 1.294. Average travel speed in the regular two lanes has remained the same as pre-project levels at 38 mph, while the average speed on the preferential lane was 52 mph. Travel time for preferential lane users is 3.88 minutes, a savings of 1.39 minutes over regular lane users. Accident rates increased initially but have returned to those of pre-project conditions. This low accident rate can be attributed to the short length of the preferential lanes and the central destination of users and resulting low volumes of weaving movements across regular lanes of traffic. Violation rates were initially high but with random concentrated enforcement efforts, rates have remained below 20 percent.

The Banfield preferential lanes have been well received by commuters primarily because regular lane users have not been adversely affected by them. Travel speeds for regular lane users has not decreased and congestion and accident rates have remained rather constant.

The short length of the lanes has also contributed to their acceptance.

The lanes resulted in only minor increases in vehicle occupancy rates and transit ridership. The project has been well promoted through transit and carpool marketing efforts that have reached a large proportion of potential users. The lack of success to some extent can be attributed to the short length of preferential lanes and the small savings in travel time.

Preferential Lane on Freeway, Southwest Expressway, Boston, Massachusetts

The Southwest Expressway in Boston is an eight lane, heavily congested route penetrating all the way into downtown Boston (Brand, 1978). The expressway is the most heavily traveled highway in the state with average daily traffic of 126,000 vehicles. The preferential large project was initiated in an effort to increase the vehicle occupancy of the roadway in anticipation of several years of reconstruction of bridge decks along the expressway. The preferential lane for buses and carpools of three or more occupants was initiated on May 4, 1977 and extended over an eight mile section between Route 128 in Quincy to the Massachusetts Avenue interchange in Boston. The preferential lane was the far left lane (median lane) in the northbound direction and operated only on weekdays between 6:30 and 9:30 a.m. This phase of the preferential lane (Phase 1) was impelemented four weeks prior to actual expressway reconstruction. These four weeks were intended to allow time for carpool formation through a massive publicity campaign, and a buildup of express bus ridership.

Phase 2 of the lane's operation commenced on the morning of June 2, 1977, by shifting the four travel lanes in the northbound direction

in the vicinity of the Massachusetts Avenue interchange at the northern end of the preferential lane to a temporary three lane detour. The far left preferential lane was carried all the way through the three lane detour. During Phase 1 and 2, enforcement of the minimum vehicle occupancy was on a voluntary basis and no citations were issued.

Phase 3, the enforcement phase began on October 18, 1977. Vehicles with less than three occupants traveling in the lane were subject to a fine of $20.00. During this enforcement phase the officer was not required to stop and cite the violator on the spot because of safety consideration, but simply noted the vehicle's license plate number and the citation was issued by mail. Two weeks after the enforcement phase began, November 2, 1977, the preferential lane was closed down by the Massachusetts Department of Public Works in response to strong public opposition against the lane. Enforcement on the lane had moved violators back into the regular lanes and casued increased congestion and travel times for nonpreferential lane users.

Transportation improvements implemented in conjunction with the preferential lane included, carpool matching assistance, one new express bus route with 20-minute headway, and upgrading and expansion of seven existing and two new fringe parking lots.

Total capital cost of the project was approximately $93,000 with the following breakdown in expenditures: signing and pavement marking $8,000; Marketing $40,000; plastic lane delinators (3500 @ $11) $39,000; and drilling of holes for delinators (1500 @ $4) $6,000. Installation and removal of plastic delinators each week was $3,750 for a total operational cost of $97,000.

During Phase 1, the number of carpools with three or more occupants increased by 37.7 percent over pre-project conditions from 877 to 1,208 at Southampton Street near the end of the lane while bus ridership increased only 2.9 percent from 3,400 to 3,500. During the same period, the number of vehicles using the expressway in the morning peak period (6:30 - 9:30 a.m.) dropped from 19,424 to 17,537, a 9.7 percent decrease while the number of people carried decreased by only 4.0 percent from 27,916 to 26,780. Vehicle occupancy increased during this time from 1.31 persons per vehicle to 1.40 persons per vehicle, a 6.9 percent change. Travel time savings for preferential lane users averaged two to three minutes faster than the regular lane users and three to six minutes faster than pre-project conditions. For the peak period, the preferential lane carried 37 percent of all persons using the expressway in 22.2 percent of all vehicles.

During Phase 2, the number of carpools decreased by 98 from Phase 1 at Southampton Street while bus ridership remained constant. The total number of vehicles and persons using the expressway continued to decrease from Phase 1 to 13,740 vehicles and 21,800 persons, a 29.3 and 21.9 percent decrease respectively from pre-project conditions. This large reduction in vehicle volumes is accounted in diversion of commuters to alternative modes of transportation (Red Line Rapid Transit, Commuter rail and commuter boat), 11 percent of vehicles; increased auto occupancy through carpooling, 11 percent; shifting to alternative street routes, 62 percent; shifting travel time, 5 percent; and not making the trip, 11 percent. During Phase 2, the preferential lane carried 46 percent of the total persons using the expressway in 30.7

percent of the vehicles. Average auto occupancy increased to 1.41 persons per vehicle while travel time decreased two to three minutes for preferential lane users over Phase 1 operations. The compliance rate (percent of total vehicles in the preferential lane which are buses and carpools with three or more occupants) during Phase 1 and 2 was very low and averaged 36 percent at the beginning of the lane and decreased to 20 percent as its end. Accident records show the number of accidents with the preferential lane were comparable to those of past experience. During Phase 3, the enforcement phase, carpools with three or more occupants increased 71.2 percent over pre-project conditions from 681 to 1,166 at Furnace Brook Parkway. Approximately 225 of these 485 additional carpools were newly formed during the two week enforcement period. Express bus ridership was showing an upward trend during the two weeks of enforcement with an increase of about 100 riders over Phase 2 levels. The total number of vehicles using the expressway decreased from pre-project conditions by 14.4 percent (2,333 fewer vehicles), but the total number of persons decreased by only 8.2 percent (1,937 persons). This represented an increased in auto occupancy from 1.30 to 1.39 persons per vehicle in the peak period. The preferential lane carried 31.7 percent of all expressway commuters in 11.8 percent of the total vehicles during Phase 3. Travel time for preferential users was similar to Phases 1 and 2 but regular lane users experienced travel time increases of four to eight minutes over pre-project conditions. This increased travel time and resulting congestion on the expressway and surface streets were major issues in stimulating adverse public opinion and the eventual closing of the lane.

Preferential Lane on Freeway, Shirley Highway, Washington, D.C.

This exclusive freeway facility (I-95) in the suburban Washington, D.C. metropolitan area has a two lane roadway constructed in the median strip on a 12 mile section from the Springfield area of Northern Virginia into downtown Washington, D.C. (Rothenberg, 1977; Allen, 1977). Starting in late 1969, buses were given priority use of the lanes and in December 1973, the facility was also opened to carpools with four or more persons, but carpools were not allowed to travel in the exclusive lanes all the way into downtown. In October 1975, the exclusive lanes were opened to carpools for the entire length of the facility and from February to October 1976, carpools were allowed use of additional access points to the preferential lanes throughout its length.

At the start of the project, 2,000 persons in 38 bus trips used the highway during the two and one-half hour morning peak period (Miller, 1976). In the summer of 1975, there were 13,781 bus passengers on 304 trips using the Shirley Express Lanes. Bus ridership peaked in March 1976 with 14,803 passengers and has steadily declined since May 1976. The total bus passenger volumes for all entry points has shown a decline of 11.5 percent. This reduction occurred since the express ramps were opened to full use by carpools. Of carpool commuters using the preferential lane, 22 percent of 600 individuals said they regularly commuted by bus prior to the ramp openings.

From the opening of the lanes to carpools in 1973 to February 1976, the lane carried some 1,700 carpools. The addition of the preferential access lanes has increased the number of carpools to 3,000. This increase in carpool volumes was attributed to shifts from other

facilities and transit rather than formation of new carpools. Only 18 percent of the persons now in carpools previously drove alone.

Travel time savings of 15 to 20 minutes have been reported by users of the preferential lanes. The express lanes have attracted carpools from areas not normally included as a part of the corridor. During the a.m. peak period, 560 carpools reported traveling about three miles out of their way while 300 traveled six miles out of their way. Twenty-five percent of carpool commuters said they formed carpools only because the facility existed.

Allowing carpools use of priority ramps has not created a safety problem nor have their numbers caused significant delays at either entry or exit points. Enforcement has not been a problem with violations remaining below three percent of all carpools using the lanes.

PARK AND RIDE FACILITIES

Park and Ride Facilities, Michigan Department of State Highways and Transportation

In 1974 the State of Michigan initiated a carpool parking lot program by constructing 11 park and pool lots (Michigan, 1978). By 1978 there were 98 lots constructed throughout the state with a capacity of 1,670 spaces. All lots are located within state highway right-of-way and constructed and maintained by state maintenance crews. Lots were financed 100 percent with state funds. The majority of lots are small gravel covered lots ranging in capacity from 10 to 100 spaces. Total lot usage averages 750 parked vehicles per day.

Park and Ride Facilities, Kansas City/St. Joseph and St. Louis, Missouri

In 1974 the State Highway Department initiated construction of commuter parking lots in the St. Louis and Kansas City/St. Joseph areas (Missouri, 1976). By March 1976, the Departmnet had constructed within state right-of-way, six commuter lots in the Kansas City/St. Joseph area and 13 in the St. Louis area. These 19 lots have a capacity of 776 parking spaces. Since 1976 an additional 13 commuter lots have been constructed on state right-of-way and six of the existing lots were expanded to increase capacity to 1,465 spaces. All 32 lots were constructed by state maintenance forces and financed 100 percent by state funds. The total cost of constructing the lots was approximately $220,000 and ranged from $85 to $463.

A survey of users at the initial 19 lots was conducted in March 1976, and indicated that about 60 percent of the parking spaces were being utilized on a daily basis. At the Kansas City/St. Joseph lots,

usage rates ranged from 10 to 33 percent and averaged 44 percent. One-way trip lengths from commuter lots to destination averaged 28.6 miles and ranged from 11.9 to 52.5 miles. Forty-six percent of the commuters using the lots indicated they did not carpool prior to the opening of the lots. Vehicle occupancy averaged 3.4 persons per vehicle. At St. Louis, usage rates averaged 64 percent and ranged from zero to 21 vehicles over capacity. Commuting distances from the lots to final distinations ranged from 6.5 to 102 miles oneway and averaged 25.9 miles. Of the commuters utilizing the lots, 56 percent indicated they did not carpool before the lots were opened. Vehicle occupancy averages 3.5 persons per vehicle.

Users experessed the opinion that the lots were a wise use of tax monies but felt the lots should be lighted and more patrolling was necessary to reduce vandalism and thefts.

Park And Ride Facilities, Portland, Oregon

The local transit property (Tri-Met) operates 73 park and ride lots throughout the Portland metropolitan area (DiRenzo, 1979; Tri-Met, 1979). Tri-Met does not own or lease any of these lots but rather makes agreements with churches, businesses, shopping centers, and other organizations for donated facilities. Lots are both paved and gravel covered. Each of the 73 lots offers free parking with the number of available spaces per lot varying from 10 to 300. Each lot is served by one to four bus lines.

The total number of vehicles using the lots has increased from 2,132 users in 1977, to 2,452 users in 1978 to 2,652 in October, 1979.

During 1979, the number of people parking at the lots four or more days a week has increased from 79 percent to 84 percent of total users. Seventy-eight percent of the respondents indicated the availability of the lots influenced then to ride the bus, or join a carpool or buspool. Eleven percent of the respondents either carpool to the park and ride lots or form a carpool at the lots.

Results of an October 1978 survey of lot users yielded the following results:

- Ninety-two percent of the respondents use the lots to catch a bus;
- Ninety-three percent of the respondents arrive at the lots by driving alone in their cars;
- The average distance traveled to the lot by persons commuting less than 10 miles is 3.09 miles;
- For those that travel 20 miles or less, the average distance traveled by the respondents from the lots to their destinations is 11.6 miles; and
- Twenty-three percent of the respondents patronize adjacent businesses at least once a week and 35 percent patronize adjacent businesses occasionally.

PARKING MANAGEMENT TECHNIQUES

Restrictions on Number of New Parking Spaces, San Francisco, California

In 1968, the City of San Francisco adopted revisions in their zoning ordances by removing restrictions on the supply of off-street parking that must be provided for new developments in the C3 zones (Di Renzo, 1979). Currently no minimum amount of off-street parking is required and if accessory use parking is provided, only seven percent of the gross floor area may be provided as parking.

Two parking surveys of the downtown were conducted in 1965 and 1975. These surveys reported that the number of off-street parking spaces grew from 43,701 in 1965, to 53,744 spaces in 1975 (2.1 percent annual growth rate). Considering that the average annual growth rate from office development was 1,565,000 gross sq. ft. per year for 1970-1977, this increase is moderate.

Limit Number of New Parking Spaces, Boston, Massachusetts

The City of Boston in conjunction with state support, introduced the concept of a freeze on the construction of new off-street commercial parking spaces in 1975 through a Transportation Control Plan (TCP) promulgated by the U.S. Environmental Protection Agency to achieve federally mandated clean air requirements. The freeze originally proposed a ban on new off-street employee and commercial parking, but the plan which was finally adopted excluded the former restriction. The freeze on commercial, for-hire spaces inhibits developers who wish to build new retail centers and places no restrictions on the amount of free or private employee parking which may be built. In December 1976 the freeze was authorized and implemented through the Boston Air Pollution Control Commission (BAPCC).

To implement the Freeze, Boston first had to establish the number of commercial off-street parking spaces as of October 1973 to determine the freeze level. The parking freeze stipulates that the supply of off-street commercial spaces may not exceed the level which existed as of October 1973. There are 400 off-street facilities in Boston with a total of 54,452 spaces. Of these, 35,503 are defined as general purpose commercial off-street, and this has been certified as the 1973 freeze level. As long as the number of off-street, commercial spaces equals the freeze number, no additional parking of this nature may be built. To permit the construction of new spaces under the freeze, old spaces must be eliminated on a one-for-one basis. Boston operating agencies refer to the freeze system as the freeze "bank" and the number of spaces which may be potentially developed as the "balance." Only commercial parking spaces and legal on-street spaces which have been physically eliminated shall be counted as replaceable with new construction (i.e. credits). Administrative regulations to remove parking spaces (e.g., parking bans) are not counted as eliminations.

Construction or modification of commercial parking facilities may not commence without a Parking Freeze Permit. A commercial parking space is defined as any off-street parking space which is available for use by the general public for a fee at any time of the day. Excluded from this restriction are parking spaces limited exclusively to residents or users of residential buildings (e.g., hotels); private, free parking; and parking on public streets. Permits will be granted by the BAPCC if the applicant can satisfy the following criteria:

- spaces in parking bank available;
- it will not add commercial off-street parking in an area which is already adequately served by existing parking facilities;
- it will not contribute significantly to traffic flows during peak traffic periods;
- it is located and designed so that the surrounding sidewalks and streets are sufficient to accommodate pedestrians and vehicular movements;
- it has satisfactory access to the major highways serving the area;
- it directly served development in the surrounding area; and
- its design, including height, bulk, ground floor use, and landscaping, is in accordance with and consistent with architectural and land use patterns in the surrounding area and is itself esthetically pleasing.

No costs data were available on the operation of this program. Parking Freeze Permit applications require a substantial amount of administrative processing and coordination with other city agencies. The initial costs of inventorying existing facilities was also a substantial undertaking.

Since the program was initiated, 926 spaces in public lots and 446 on-street spaces have been eliminated; which provide a total of 1,372 potential development credits in the freeze bank.

Over 1,000 spaces have been granted to developers. The impacts of the policy (if any) are difficult to assess. The program took several years to plan and implement and developers had the opportunity to build parking during this period in anticipation of the freeze. City officials believe that no developer has been deterred from pursuing downtown projects because of the freeze.

BAPCC supports an extension of the freeze definition to include employee parking spaces. Expanding the definition would better achieve the TCP goals of reducing auto commuting by increasing the number of spaces covered from 35,000 to 50,000. From the perspective of sustaining downtown retail activity, expanding the definition would permit the city to apply employee parking space eliminations to the construction of new commercial spaces, thereby increasing the short-term parking supply and decreasing the long-term supply and reducing peak traffic flows and VMT.

Restriction on Supply of New Parking Spaces, Portland, Oregon

To help control the supply of downtown parking, the City of Portland enacted zoning restrictions that sets a maximum limit on the provision of parking for new development but sets no minimum (Di Renzo, 1979). The Bureau of Planning is responsible for implementation.

The applicable Planning and Zoning Code is Section 33.56.90, Parking Requirements. The section reads as follows:

> There shall be no minimum off-street parking requirements in the Downtown Development Zone. The allowable number of private off-street parking spaces, when permitted as a conditional use, shall be determined in accordance with the following schedule:

Development Type	Spaces per 1,000 square feet of Gross Floor Area, of per Habitable Unit
Residential	1.20 per Dwelling Unit
Hotel	1.00 per Rentable Unit
Retail	1.00 per 1,000 square feet
Office	1.00 per 1,000 square feet
Medical	1.50 per 1,000 square feet
Educational	1.00 per 1,000 square feet
Cultural/Entertainment	0.25 per 1,000 square feet
Manufacturing/Wholesale	0.70 per 1,000 square feet

This zoning restriction in conjunction with the other parking and transportation system management tactics have resulted in the provision of one parking space per 1,350 square feet of gross floor area for new development in downtown Portland compared to a national average of one space per 650 square feet.

Limit on Number of Parking Spaces, Portland, Oregon

In February 1975, the City Council adopted a parking ceiling program which was part of an overall downtown parking and circulation policy (DeRenzo, 1979). The Portland Bureau of Planning was designated to plan and coordinate downtown parking, to administer the policy on parking and circulation, and process all applications for new parking spaces.

The total number of parking spaces (on-street and off-street) available for use in the downtown is not permitted to exceed 38,870. This number was established by a parking survey in 1973 as the number of existing plus committed spaces. New parking spaces for residential and hotel uses are exempt form this limit. The downtown was also divided into six parking sectors and as a guide to public and private investment, sector allocations were suggested as a goal for 1990.

Every new development in downtown Portland is reviewed and approved by the Planning Commission before a building permit is issued. The Bureau of Planning provides input on the areas which affect the parking policy. There are four questions which are asked by the Bureau of Planning concerning parking for new developments:

- Does the requested parking exceed the ceiling?
- Are the maximum parking to floor space ratios exceeded?
- Does the requested parking conform with the parking sector goals?
- Does the requested parking promote the goal of increasing short-term parking spaces over the provision of long-term spaces?

When the developer can answer these questions to the satisfaction of the Planning staff, then the parking segment of the development is approved. The Bureau of Planning coordinates with the Portland Development Commission so that prospective developers are fully informed of the parking ceiling. However, the entire development must conform to the City development policies and applicable codes before a building permit will be issued by the Planning Commission.

This parking review function was added to the Bureau of Planning duties as part of the overall development review function which the Bureau performed for the Commission previously. The Bureau has one full-time senior person assigned to downtown planning with additional assistance allocated as the need arises.

The parking ceiling has not been exceeded at this time. However, the Bureau of Planning has seen the major achievements of the ceiling as:

- o encouraging the provision of parking in the desired parking sectors; and
- o encouraging developers to provide one space per 1,200 to 1,300 square feet of gross floor area as opposed to a national average of one space per 650 square feet.

According to the Portland Development Commission, development in the downtown area has not been hurt by the parking ceiling.

Off-Street Parking Reduction, Pittsburgh, Pennsylvania

An example of a severe reduction in parking supply occured in a 1972 parking strike in Pittsburgh. The strike caused a closing of 80 percent of the parking spaces in downtown. During the strike, morning peak period traffice volumes in the CBD declined by about 24 percent (6,000 vehicles) and daily systemwide bus patronage increased by about 12 percent (or 24,000 daily riders). Approximately 75 percent of commuters used transit during the strike. During the strike, retail sales decreased an average of six to eight percent, theaters reported patronage losses of 60 to 70 percent and other entertainment facilities and restaurants reported losses of business ranging from 10 to 70 percent.

Limitation on Number of New Parking Spaces, Seattle, Washington

As part of an overall downtown parking policy adopted in mid 1975, the City of Seattle initiated revisions in their zoning ordinance toward the minimum and maximum number of parking spaces that can accompany new developments. In October 1976, a revised zoning ordinance was

adopted that created two zones in downtown Seattle were parking restrictions would be initiated. Zone A is the core central business district and Zone B is the remainder of downtown. Primarily, new principal use parking garages and all types of parking lots are prohibited in Area A. Principal use parking lots and garages is a conditional use in Area B. The ordinance sets a maximum on the number of parking spaces that can be provided for new development in the CBD (Area A). Banks, businesses, or professional offices in buildings where such uses occupy at least 80 percent of the gross floor area (GFA) are permitted the following:

- o one parking space per 1,000 sq. ft. of GFA in the metropolitan commercial zone; and
- o one space per 1,500 sq. ft. of GFA in the metropolitan business and manufacturing zone.

If the utilization of the building is for less than 80 percent of the above uses, then the following is allowed:

- o One space per 1,200 sq. ft. of GFA in the metropolitan commercial zone; and
- o one parking space per 2,000 sq. ft. of GFA in the metropolitan business and manufacturing zone.

There is no minimum parking requirement.

The provisions of the zoning ordinance must be met before the required building permits will be issued by the Department of Building. However, each building development is also required to prepare an Environmental Impact Statement (EIS) which includes a section on transportation and circulation impacts. The EIS must offer measures to mitigate the effects of adverse impacts of which parking is one of the areas addressed.

The effects of parking are also specifically addressed in the revised zoning ordinance and states that a city offical or authorizing agency may require measures to mitigate adverse parking impacts, including requiring preference of some parking spaces for carpool or vanpool vehicles. Already some office developers have agreed to reserve 10 percent of their parking supply for carpools. These spaces would be in preferred locations and also would have reduced parking rates. The EIS review and issuance of building permits gives the City significant leverage to control parking supply. The parking policy as implemented by amendments to the zoning ordinance requires a biannual review.

Since the enactment of the parking restrictions the supply of public spaces in the downtown has declined by 5.5 percent from 31,779 in 1976 to 30,022 spaces in 1978 (Seattle, 1979). The majority of lost spaces has been in Area B and is the combined result of converting off-street spaces from public to private use and removing on-street spaces. Private off-street spaces has increased 5.7 percent from 12,863 spaces in 1976 to 13,602 in 1978. Overall, the total parking supply in downtown declined 2.3 percent from 44,642 spaces to 43,624 in 1978.

Since the zoning ordinance was revised, 13 major new nonresidental developments have been proposed in Areas A and B. These new developments have been providing parking at 50 to 60 percent of the maximum allowed and is basically a result of minimizing costs. Developers are providing the minimum amount of parking that they believe is required to attract tenants.

On Street Parking Restrictions, Boston, Massachusetts

An on-street parking ban was originally implemented as part of the Boston Transportation Control Program in 1975. Parking is restricted on all streets within Boston Proper between 7 and 9:30 a.m. and 4 to 6 p.m. to discourage auto commuters. Currently two-thirds of the streets have been signed to date. The city wide residential parking permit program was implemented around this time in part to exempt residents from these restrictions. Many arterials already had peak hour restrictions. Approximately $150,000 has been spent for signs and their placement.

Strict enforcement is essential if this tactic is to be successful. Unfortunately, enforcement responsibilities have been divided amoung four agencies with jurisdiction in this area;

- o City Policy Department;
- o Traffic and Parking (meter maids);
- o Metropolitan District Police (MDC), responsible for parks and major access roads; and
- o Capitol police, responsible for state grounds and adjacent streets.

Enforcement performance varied among the agencies. Traffic and Parking was initially enthusiastic about the program and assigned several meter maids; however, budgetary pressures forced a later reduction of effort. The Boston police played a limited enforcement role and the MDC assigned five officers after repeated requests by the city. City officials indicated that Capitol Police took little interest in the program. City officials do not foresee a major allocation of resources for this

parking management tactic. The costs of enforcing the restrictions are prohibitive and poor ticket collection by the city reduces the policy's cost effectiveness. The policy has also engendered strong opposition from schools and institutions whose short-term parking clientele are adversely affected.

Residential Parking Permit Program, San Francisco, California

The City of San Francisco currently operates three residential parking permit areas. The areas were implemented between August 1977 and December 1978 (DiRenzo, 1979). The permit programs were initiated as a result of long-term parking by non residents. Permits are distributed by the Tax Collector's Office for a first time cost of $10 and $5 for renewal. To renew, residents must have a valid driver's license and vehicle registration, both of which show that the individual's residence address is in the permit area. There are two exceptions, businesses in the area are allowed one permit and residents who rent vehicles are given seven day permits. Visitor's permits are available for a two week period. The Tax Collector maintains a list of street addresses which are within the permit area for determining eligibility.

When the permit program was first initated in the Telegraph Hill-North Beach-Russian Hill area, permits were sold at two locations and the issuance of two permits to the same person was not checked during a one year period, 12,000 permits were sold in this area compared to 4,191 legal on-street spaces available. Enforcement of the permit program is provided by the Police Department's civilian parking patrol.

To implement a new permit area the following steps must be followed:

- A neighborhood group contacts the Department of Public Works, Division of Traffic Engineering and expresses a desire to establish a residential parking permit program.
- The boundaries of the affected area are determined by the Division of Traffic Engineering and the neighborhood group.
- The neighborhood group obtains signed petitions from a majority of residents in the affected area reflecting a desire to institute the program.
- The Division of Traffic Engineering conducts a parking study of the area. The following criteria must be met:
  - peak occupancy must exceed 80 percent; and
  - 50 percent of the vehicles parked in the area during peak occupancy must be commuter vehicles.
- A public hearing is held and the matter is turned over to the Board of Supervisors (i.e., City Council).
- Finally, the Board of Supervisors passes a new ordinance for each area designating the creation of a residential parking permit program there.

The programs has been successful in eliminating nonresidential parkers in residential areas and reducing traffic congestion. Residents responding to a survey favored the continuance of the program.

Residential Parking Permit Program, Baltimore, Maryland

A Residential Parking Permit Program (RPPP) was implemented in the Oakenshawe neighborhood of Baltimore in September 1976, to prohibit all day parking by employees of a nearby, major hospital complex (Di Renzo,

1979). The neighborhood is primarily composed of duplexes and row-houses located about 1.5 miles north of the CBD. Approximately 250 to 300 households are covered by the program.

The RPPP was implemented under "emergency powers" of the Commissioner of Transit and Traffic. Under city statutes, the Commissioner may initiate traffic regulations which he feels are warranted for a trial period of six months. At the end of this trial period, the City Council may veto the measures. The city council chose not to veto the RPPP in Oakenshawe and consequently, it has remained in effect. The program was latter challenged in a Maryland court, but the authority of the Commissioner was upheld in March 1978.

In March 1979, the City Council enacted an ordinance (No. 999) which makes the creation of RPPP's in other parts of Baltimore normal, administrative actions. The ordinance creates eligibility criteria which must be applied before an area is selected for an RPPP. A study must be conducted and both of the following criteria must be met before an RPPP will be considered:

- At least 80 percent of the curb parking spaces in an adjacent 10 block area or area containing 100 curb spaces were utilized during peak periods.
- Twenty-five percent of the curb parking spaces in the area were utilized by nonresident parkers who were parked for two or more hours.

City officials have identified neighborhoods around subway stations currently under construction as possible future sites for RPPPs.

The Oakenshawe RPPP covers approximately 20 block faces, and nonresident restrictions are in effect 24 hours per day, Monday through Friday. On-street parking without a sticker is permitted for two-hour durations. Each household covered by the program is entitled to one sticker for each car it owns and two additional visitor permits. There are generally two or three signs on each block face with the posted regulations.

The police department is responsible for enforcing the program, and has proven to be relatively easy and straight forward. Fines for violations are $7 and there was active ticketing during the commencement of the program. Compliance is currently good according to city officials, and the police largely rely upon resident complaints to identify habitual violators.

Program cost have been virtually all one-time, startup in nature. The approximately 50 signs which have been posted have a fabrication cost of $40 each (plus installation costs). The resident stickers were distributed by the Department of Transit and Traffic at a city owned location near Oakenshawe. Prior to selling the stickers, the department distributed flyers to about 400 households and placed news releases in the local media. The original initial purchase price for the sticker was $10; the new RPPP ordinance sets the fee at $5 per vehicle.

The RPPP has successfully reduced the on-street parking problem for neighborhood residents. The hospital owned parking garage is now used to a greater extent by the displaced parkers.

Residential Parking Permit Program, Montgomery County, Maryland

Montgomery County, Maryland, is a suburban county located on the northern border of Washington, D.C. Its current population is approxi-

mately 600,000. The mix of development varies from several high density commercial centers to low density suburban housing.

In June 1978, a Residential Parking Permit Program (RPPP) was initialed in the neighborhoods of East Bethesda and Huntington Terrace (DiRenzo, 1979). The programs restrict parking to permit holders between 9 a.m. and 5 p.m., Monday through Friday. Permits are sold at $5.00 per year with one free visitor's permit issued per dwelling unit. Nonresident, commercial, and service vehicles are exempt from the restriction when conducting business in the area. Implementation costs for the approximately 70 block face Huntington Terrace program were approximately $4,000 administration and planning, $1,823 installing 132 signs, and $1,132 in materials.

In designating new areas the Division of Traffice Engineering responds to interest from neighborhood residents. Working with the residents, the Division defines the area which is impacted immediately and a wider area that could be impacted ultimately. Once the permit program area is defined, the neighborhood association is requested to obtain petition signatures from two-thirds of the affected residents. The Division also conducts a study to determine if the area meets the following technical qualifications:

- At least 25 percent of the area dwelling units have less than two off-street parking spaces.
- Average occupancy is greater than 50 percent between 8 a.m. and 5 p.m.
- At least 50 percent of the existing on-street parking population are nonresidents.

If a street is already signed for limited parking, it is assumed to meet the second and third criteria above. A public hearing is then held and if all results are favorable, the residential parking permit program is established for the area.

No formal before and after studies have been conducted, but the Division of Traffic Engineering reports few if no parking complaints from residents once the program starts.

Residential Parking Permit Program, Boston, Massachusetts

Two Residential Parking Permit Programs (RPPP) are currently operating in Boston; a city wide program and the Becon Hill RPPP (Di Renzo, 1979). Boston's city wide RPPP is designed to exempt residents from two parking restrictions which are primarily aimed at discouraging auto commuters. The first restriction limits parking on all city streets to two hours and is in force 24 hours a day. The other restrictions prohibits parking on posted streets from 7 to 9:30 a.m. and 4 to 6 p.m. The Beacon Hill RPPP is a variation of the city wide appoach that prohibits nonresident parking at all times except in designated spaces. Resident parking is permitted in spaces reserved for residents only.

Three is no charge for the resident stickers in either program. Stickers are distributed at Boston's Little City Halls (neighborhood city offices) for each valid Massachusetts auto registration submitted. The city wide RPPP has 12 neighborhoods and stickers are coded with a letter to designate each district. Residents must park within their neighborhood for the sticker to be valid. In the Boston Hill RPPP

vehicle registration numbers are printed on resident stickers at the time of issuance to forestall counterfeiting problems which had developed in select areas under the city wide program. Stickers are renewed annually in both programs to maintain management control.

Enforcement is typically concentrated in areas where all day commuter parking is creating problems. Police generally respond to neighborhood complaints rather than systematic monitoring as the costs of covering the entire city are prohibited. Fines for violating the Beacon Hill RPPP are $10.00 compared to city wide RPPP fines of $5.00.

Evaluation of the RPPP by the Traffic and Parking Department reported that the program is accomplishing its twofold objective of increased parking supply for residents and reduced congestion in the area. Enforcement costs associated with new area applications like that of Beacon Hill may inhibit effective police support since well patrolled areas are essential for effective results.

Residential Parking Permit Program, Eugene, Oregon

Between October 1978 and late March 1979, the City of Eugene conducted a test of a residentail parking permit program in a neighborhood which is impacted by The University of Oregon student parking (DiRenzo, 1979). Each block within the 140 block area was allowed to decide whether they wanted to be part of the program or not. Only 33 blocks agreed to participate. Nonparticipating blocks have a two-hour limit on parking.

The parking permit which costs $5.00, allows the residents to park for more than two hours on the 33 blocks which are signed. The parking

restrictions are in effect from 9 a.m. to 3 p.m., Monday through Friday. Sixty permits have been sold out of an anticipated 400.

The City has indicated that many nonpermit parkers have shifted to nonrestricted streets. Thus indicating that partical application in an area may just create worse conditions on nonrestricted streets.

Residential Parking Permit Program, Arlington County, Virginia

Arlington County (population 153,000) is located across the Potomac River from Washington, D.C. and has experienced major residential and commercial growth pressures in recent years (Di Renzo, 1979). In response to severly congested neighborhoods by all day parking from neighboring employment and commercial centers, Arlington instituted their first Residential Permit Parking Program (RPPP) near Cyrstal City in 1977. The original RPPP boundaries were expanded shortly after implementation as displaced parkers shifted their demand to the periphery of the district. Currently, about 110 blocks throughout the county are covered by resident parking restrictions in three separate zones.

Permit programs are initiated in response to phone calls, letters, and petitions concerning neighborhood parking problems. The area is evaluated by the Traffic Engineering Division, by inventorying each street segment for potential parking spaces and then performing a parked vehicle count by street during the period of maximum parking accumulation. If 75 percent of the spaces are occupied during the survey and 25 percent of the parkers are destined to commercial or industrial areas, then streets which meet these criteria are eligible for resident parking only classification.

After a street has been designated as a permit parking area by the zoning administrator (the RPPP is an amendment to the zoning ordinance), residents are notified that free permit stickers may be acquired at a designated fire station. Residents are also entitled to two visitor permits for overnight visitors (valid up to 30 days) and guest permits for daytime visitors. Service and delivery vehicles do not require permits, and persons conducting business in unmarked private vehicles may request a permit from the fire station. For social activities, police will issue permits which are valid for four hours on one day on specific streets. The number of special permits issued at one time may not exceed 50 percent of the potential parking spaces on those streets.

No systematic study of program impacts has been conducted to date, but the traffic department feels the program has successfully achieved its objective of eliminating nonresidential parkers. Enforcement has been good, and the county foresees creating additional RPPP zones as the Metro System is completed.

A related parking management tactic employed by the county permits developers to reduce their parking requirements if the site is located near a station of the region's Metro rapid transit system. Under this parking policy, developers may provide about 70 percent of the parking ordinarily required for a similar project not in the vicinity of a Metro station. Developers have taken advantage of this relaxation of parking requirements to reduce their construction costs.

Residential Parking Permit Program, Washington, D.C.

Beginning in October 1974 the District of Columbia implemented Residential Parking Permit Programs (RPPP) throughout the District and

currently 12 to 15 percent of all residential streets (1,400 blocks) are covered by the program (DiRenzo, 1979). Residential areas are designated as permit areas through petition by residents. After a majority of residents along a block support a permit program, the D.C. DOT conducts a parking study to see if the area meets program criteria. To qualify, 70 percent of the legal spaces must be occupied and 10 percent of the vehicles parked must be from out of state. The Mayor and City Council review the facts and the area is then approved as a permit zone.

To qualify for a permit the resident must register the vehicle in the area unless an out-of-state license reciprocity stricker has been issued. Permit stickers cost $5 per year and are handled by one office. Free visitor passes are available at local police stations. Vehicles without permits are only allowed to park for two hours during the posted times. Estimated annual costs for a typical 100 block RPPP in the District is $15,000 with the following break down:

- o $5,000 as the annualized cost of sign labor and materials;
- o $5,000 for administration, computer support, and overhead;
- o $3,000 for clerical labor to issue permits and maintain the necessary records; and
- o $2,000 for printing the permits and purchase of necessary supplies.

D.C. DOT conducted before and after parking studies in two permit areas, Friendship Heights and Georgetown. Results showed that occupancy fell dramatically in both areas in addition to a decrease in illegally parked vehicles in the Georgetown area.

Preferential Parking for Ridesharers, Little Rock, Arkansas

At the state government facility in Little Rock, Arkansas, 500 close-in parking spaces were designated for carpoolers, as well as, a requirement that all state-owned cars must have at least three passengers if taken home at night. These changes caused the number of state employees in carpools to rise from 400 to 1,000.

Preferential Parking for Ridesharers, Caltrans, Sacramento, California

In February 1974, the California Department of Transportation (Caltrans) initiated a preferential carpool parking program in the employee parking lots serving the Sacramento headquarters office (Derby, 1977). The program was undertaken in response to the energy problems of 1973-74. Carpools with three or more occupants were given close in parking spaces at lots adjacent to the employement site. Parking costs are $10.50 per month for both single occupant autos and carpools. The most distant parking space for nonpoolers requires walking approximate two city blocks.

In February 1974, when priority parking was first initiated, 91 carpools were registered for spaces, filling 22 percent of the total 414 available spaces. By July 1977, 159 carpools were registered in the then 447 available spaces. A survey of these 159 carpools with responses from 79 indicated that 29 percent formed or expanded a carpool to take advantage of the priority parking facilities. Half of the carpoolers were carpooling prior to the program and 41 percent drove alone. The average vehicle occupancy of carpools was 3.5 and the average oneway commuting distance was 13.5 miles. The priority parking

program has been quite successful and well received by employees. Noncarpoolers have expressed little criticism of the program primarily because walking distances are only one or two blocks long. The success of the program can also be attributed to supporting programs of computer matching, flexible work hours allowing employees to meet the schedules of other commuters, and marketing activities designed to encourage increased vehicle occupancy.

Preferential Parking for Vanpools, San Francisco, California

The California Department of Transportation (Caltrans) owns property under the elevated freeway just south of downtown San Francisco (DiRenzo, 1979). This property has been leased to parking lot operators for use as public parking lots. To encourage ridesharing Caltrans required that selected lots be reserved for certified carpools only. A survey of lot users indicated that most of the new carpoolers had been transit riders before this program began and it was felt that the reserved parking program was actually increasing the number of vehicles on the road.

In March 1979, the lease on three lots expired and the priority parking was changed to encourage vanpools. Parking lot operators are required to accept up to 40 percent of the lot's capacity for vanpool vehicles. The vans are charged $10.00 per month as opposed to the normal fee of $60.00 per month. Caltrans rebates the lot operator $50.00 for each van. The 40 percent figure is the break even point for the State. Carpools are no longer given any preference. As other leases are renewed, the same vanpool preference system will go into effect.

Preferential Parking for Rideshares, Baltimore, Maryland

The city of Baltimore currently reserves approximately 600 parking spaces in six different locations in or adjacent to the CBD for carpool parking as an incentive to reduce single occupant auto trips (Di Renzo, 1979). Reserved carpool parking occurs on a portion of vacant redevelopment sites through the CBD. The fee structure for the reserved parking is the same as other city operated lots, $2 per day. Parking is usually filled by 8:30 a.m. but reserved spaces are held open until 12 noon, after which it is open to general parking.

Drivers who wish to reserve spaces submit signed affidavits that they transport at least three people 80 percent of the time (weekdays only). There is a large waiting list for the reserved spaces since they are held open to 12 noon. The driver need not enter the lot with passengers, and the lots are metered without attendants. The primary cost of operating the program are those of assigning reserved spaces and handling the applications.

Enforcement is a serious problem with anticipated widespread violations. There is no penalty if a driver is caught violating the conditions of the program. More importantly there is no effort to enforce the policy. Compliance is completely voluntary, and applicants are not required to provide the names and addresses of their riders. City officials are currently discussing methods to monitor program compliance, but under present operating conditions the task is extremely difficult.

The City Department of Planning conducted an evaluation of three carpool lots in November 1977 (Baltimore, 1977). The survey found that

the majority of users were members of carpools formed prior to the implementation of the lots. The cost of parking and auto operation were the dominant reasons for forming new carpools. Abuse of the program appears widespread with 80 percent of the cars using two lots and 70 percent using the third having fewer than the required three persons.

Preferential Parking for Ridesharers, Montgomery County, Maryland

Montgomery County, Maryland is a suburban county located on the northern border of Washington, D.C. Its current population is approximately 600,000. The mix of development varies from several high density commercial centers to low density suburban housing.

In mid-1978, local planning and county transportation officials expressed an interest in developing high occupancy vehicle (HOV) parking programs for Montgomery County (DiRenzo, 1979). The Division of Parking responded with the establishment of a preferential carpool permit program.

The program reserves a total of 55 spaces in three cashier garages located in Silver Spring and Bethesda. Vehicles displaying a carpool permit are allowed to park in designated areas which are reserved for carpools. The permit is valid until 6:00 p.m., Monday through Friday. The designated spaces are reserved for carpoolers between 6 a.m. and 10 a.m., and unused spaces are available to all parkers after 10 a.m. The fee is $16 per month compared to a regular parking sticker that sells for $24 per month. Participation is limited to carpools of three or more persons which work in Silver Spring or Bethesda. The place of

employment for the members of the carpool is verified by the Division of Parking.

The reserved carpool spaces are visible to the cashiers at each of the three garages. The cashier monitors these spaces to ensure that three or more people arrive in the vehicle. The carpool permit will be revoked if misused. The parking enforcement officers check for valid stickers during their normal rounds.

In December 1978, 33 permits were sold in Bethesda and 15 in Silver Spring. Utilization of the spaces in all garages through November 1978 has been above 74 percent.

Preferential Parking for Ridesharers, Portland, Oregon

On July 28, 1977 the Portland City Council approved a downtown carpool parking program (Ordinance No. 144108) as part of the overall city policy of decreasing single occupant vehicle trips (Nelson, 1978). The program, which began in September 1977, is cooperatively sponsored by the local transit property (Tri-Met) and the City of Portland.

The program consists of 2,629 six-hour on-street metered parking spaces designated by the Bureau of Traffic Engineering. Tri-Met is authorized to issue a maximum of 500 carpool permits each month. This number was based on parking usage studies performed in the affected areas.

Carpools which display the carpool parking permit from the rear-view mirror are allowed to park at any of the above meters on an unlimited basis, Monday through Saturday. They do not have to pay the meter. Any existing parking restriction must be observed (i.e., no

parking, 4 to 6 p.m., towaway zone, etc.). The monthly fee is $15 per carpool. The permit is license to hunt for a space. A parking space is not guaranteed.

To qualify for the program, an application along with the $15 monthly fee is submitted to Tri-Met's CARPOOL project. The project staff verifies by telephone: (1) the applicant's place of employment, (2) the existence of a carpool of three or more people, and (3) the correctness of the other information on the application. The carpool is then given a certified carpool number and the permit is mailed. Only one permit is issued per carpool. The permit is transferable between cars within the pool. After a carpool has been certified and received the first monthly permit, the permits are renewable during the last two weeks of the month. To renew the permit, the carpool completes and returns the renewal form which was provided with the last permit with the $15 fee to the CARPOOL project office.

A minimum of 10 percent of all renewed carpools are reveiwed and reverified each month by the Tri-Met CARPOOL project staff. Each member of the carpool is contacted and asked if they are still in the carpool. The carpool contact person is requested to reverify the information on the carpool permit application form. If a carpool no longer meets the criteria for the program, a new permit is not issued. The project staff estimates that 5 out of 100 permit holders are in violation of program rules.

As of February 1, 1979, 288 carpools were in the program for a total of 948 people. The average auto occupancy is 3.3 persons per vehicle. Of the total carpools, 61 percent were formed as a result of

this program. The number of permits has stablized at this level because the majority of the six-hour meters are located a considerable distance from the high density employment center in the CBD and also because the meters in the most desirable locations fill up early in the monring (Tri-Met, 1979).

Preferential Parking for Ridesharers, Seattle, Washington

In mid-1976, the Seattle Commuter Pool in conjunction with the City Traffic Engineer initiated reserved on-street parking for carpool and vanpools on the fringes of the downtown area (DiRenzo, 1979). The program currently involves 164 metered on-street spaces mainly located at the south end of the downtown area. These spaces are reserved for vehicles with carpool permits between 7 and 9 a.m. The carpool does not pay the meter. Any spaces remaining empty after 9 a.m. can be used by any vehicle which pays the meter. More permits are sold than spaces so there is no guarantee that parking will be available. The monthly fee is $5 which is paid quarterly, compared to the average downtown parking cost of $39 per month.

To qualify for the program, a carpool must consist of three or more people. Each member of the pool completes an application which is reviewed by The Commuter Pool staff to determine if the pool permit has logical origins and destinations. The certified carpool is mailed one permit which is transferable between the various vehicles used by the pool. Currently there is a waiting list for permits.

The Commuter Pool makes random checks of carpools to see if they still qualify for the program. On occasion, the staff has observed

carpools arriving at the spaces and challenged by phone blatant violators. Violators can be fined ($10), have their vehicles impounded, and/or lose their permit.

Reduced Parking Fees for Ridesharers, Seattle, Washington

The City of Seattle offers reduced rate parking to carpools and vanpools at two municipally owned facilities located at the periphery of the central business district (Olsson, 1978). The municipal parking rate of $25 per month has been completely eliminated for carpools at the 219 space Pool-It lot since March 1974. In December 1977, 220 carpools were using the Pool-It lot with an average auto occupancy of 3.62. Approximately nine blocks from the Pool-It lot and closer to the city's financial district the Freeway Garage (600 spaces) offers poolers $5 per month discounted parking. This discount has been offered since May, 1976, but remains greatly underutilized with only 100 regular monthly parkers (paying the usual $25 fee) and 132 registered carpools. Monthly commercial parking fees in downtown Seattle range from about $20 on the periphery to around $40 to $50 in the heart of downtown. The average fee charged is $30.32 per month.

In an April 1977, survey of users of the Pool-It lot, the following findings were obtained:

- 62 percent of those surveyed were new carpoolers;
- 22 percent formerly drove along;
- 40 percent formerly used transit;
- 25 percent of the former auto drivers had parked free;

- parking price incentives may induce the formation of new carpools, but travel time and convenience are also considerations.

Parking Taxes, San Francisco, California

The only significant example of parking surcharges in the U.S. for which evaluation studies have been made was undertaken by the City of San Francisco in an effort to raise municipal revenues. In October 1970, a 25 percent surcharge was imposed city wide on all parking with the exception of residential, hotel, and on-street parking (Kulash, 1974). In July 1972, 22 months later, the tax was lowered to 10 percent as a result of strong opposition and loss of parking revenue by parking lot operators. Off-street parking provides approximately 50,000 spaces of which 20 percent are reserved for private use, and there are approximately 11,000 on-street parking spaces in the city.

The overall effect of the 25 percent surcharge on the number of parked cars was relatively slight. The price elasticity of parking demand from parking counts at 13 municipal garages was fairly low, ranging from -0.38 to -0.20. The parking tax also had relatively little effect on total traffic in the city causing at the most a two percent reduction in the number of vehicles using the streets. The greatest impact of the surcharge was on parking revenues due to a change in the mix of parking duration - long-term parking volume declined relative to short-term parking. On the basis of this revenue change a price elasticity of about -1.6 was estimated. This represents about a 13 percent

loss in gross revenue for a typical parking facility. Thus, the parking tax caused both a reduction in the number of automobiles parked and a reduction in the net revenues per automobile parked.

The tax had a relatively minor impact on the level of downtown retail acitivity but did have a major impact on the gross revenues and profits of the parking industry. Gross revenues were estimated to be 36 percent below the level projected under normal growth and 31 percent under those observed the year before the tax. These losses exceeded somewhat the revenues that the city and county collected from the tax which were about $5.5 million annually. During fiscal year 1977-78, the 15 percent parking tax generated 5,440,152 in revenue for the city.

FACILITY OR AREA TOLLS

Reduced Tolls for Ridesharers, San Francisco-Oakland Bay Bridge, San Francisco, California

On the San Francisco-Oakland Bay Bridge differential tolls and exclusive priority lanes for buses, carpools and vanpools has been in operation since December 1971 (California, 1979). The priority lanes and differential tolls provides rideshares a five minute time advantage and 75 cent toll savings since carpools of three or more occupants are allowed to cross the bridge free of charge. This initial effort resulted in doubling the number of carpools from 1,000 to 2,000 during the 6:00 to 9:00 a.m. peak period. The average automobile occupancy increased by about eight percent while the number of bus passengers showed no measurable change. During the morning peak period (69 a.m.) the number carpools in the priority lane is 3,100 and bus ridership is 14,300 passengers. The total number of vehicles using the bridge during the peak period remained unchanged at about 21,600.

In May 1972, in order to meet bond indenture requirements, a toll was reimposed for ridesharing vehicles. This was done by means of a carpool card costing $1.00 or five cents per day. This measure eliminated 230 carpools and moved 400 vehicles back into the nonpriority lanes.

In March 1975, when the bonds were paid off, carpools reverted back to their toll-free status. This resulted in an increase of 240 carpools above those counted in October 1974, shortly after the Bay Area Rapid Transit (BART) began service across the bay. By October 1975, peak period traffic was about the same as it had been in early 1972, shortly after the carpool lane had begun operation. Free passage of ridesharing vehicles has caused toll revenues to decrease by

about $25,000 per month. Since the reduced toll and priority lanes for ridershares were introduced at the same time and continue to operate together, one cannot conclude to what degree each has caused in shifting commuters into carpools.

Reduced Tolls for Ridesharers, Connecticut Turnpike

The Connecticut Turnpike is a 129 mile limited access toll road with eight main line toll plazas. The basic toll is 25 cents per plaza for passenger type vehicles (Rothenberg, 1977). The road serves as the major corridor along the Connecticut shore line, a distance of approximately 90 miles from the New York State line to New London. In March 1974, commuter tickets on the turnpike were reduced from $3.50 to $1.00 for a book of 42 tickets for carpools. The carpool must have a minimum of three persons when the ticket is used and is valid for a series of three consecutive toll stations for a period of 60 days. Prior to this reduction in price, regular commuter tickets were purchased for a period of thirty days. Concurrent with the carpool ticket plan, the normal commuter ticket plan was revised to allow tickets to be used at a series of three consecutive toll plazas during a 60 day period. The reduction in the price of carpool tickets is a 71 percent savings over regular commuter tickets but on an absolute basis the savings is only 5.9 cents per ticket. Thus, the percent difference is great but the absolute value of the reduction, when shared by four persons in a carpool, amounts to a few pennies per day per person.

An initial survey of users in March 1974, revealed that approximately 925 carpools were using the turnpike. Nearly half of these

carpools were already carpooling prior to reduced tolls, 12 percent did not make the trip previously and 15 percent used another route. A second survey in November 1976, indicated that the number of daily carpools had grown to 1,100 carrying about 5,000 persons and carpool ticket sales had increased by approximately 18 percent. During the same time span, regular commuter ticket sales increased 37 percent and carpool ticket sales represented only approximately 2.5 percent of total ticket sales. In the second survey, 36 percent of carpoolers were carpooling prior to the reduction in tolls and 29 percent of these previous carpoolers were diverted from parallel routes. The average oneway carpool trip length is 30 miles and passes through an average of 1.5 toll stations. Cost savings was the primary incentive for forming carpools.

The lack of a major shift to carpools can be attributed to the small monetary savings on a per capita basis which was not large enough to attract a significant number of drive along commuters. The increased time limit on regular commuter tickets and their use at three consecutive toll stations, also reduced the attractiveness of carpool ticket rates.

Reduced Tolls for Ridesharers, Evergreen Point Floating Bridge, Seattle, Washington

In an attempt to ease congestion resulting from the repaving of a bridge serving a parallel corridor (Mercer Island Bridge, I95) a two part program was initiated to encourage the use of carpools and vanpools on the Evergreen Point Floating Bridge. The first part consisted of reducing the toll on the bridge to 10 cents for carpools with three or more occupants. Regular fares on the bridge are 19.5 cents for commuters

using discount tickets and 35 cents regualr cash toll. The second part consisted of allowing carpools with three or more occupants to use an existing two mile preferential lane for buses in the inbound direction. The lane is located on the right shoulder of the four lane undivided highway approaching the bridge. The preferential lane saves bus and carpool users between six and eight minutes in travel time. The lane is in operation from 6:30 to 9:30 a.m. weekdays.

The percent of commuters in carpools with three or more occupants has increased from 6.2 percent to 17 percent since the introduction of these incentives. Overall, the percent of commuters ridesharing increased only three percent from 33 to 36 percent and indicates that commuters in most instances combined together existing carpools rather than solicitating drive alone commuters. Total passenger volume has increased on the bridge, even after the completion of resurfacing and indicates the increase in three person carpools may also be the result of diversion from the other bridge.

VITA

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