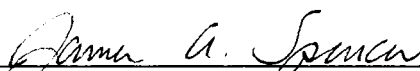
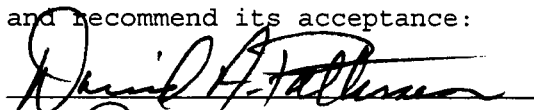
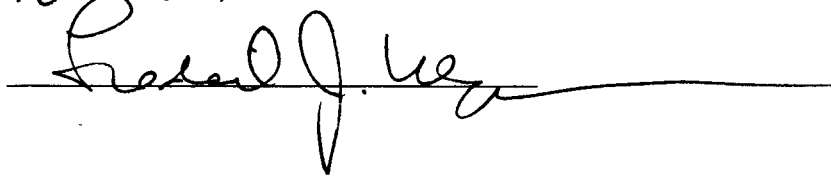


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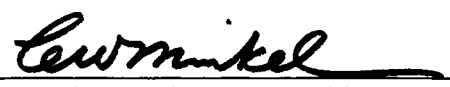
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James A. Spencer, Major Professor

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**AN EXPLORATION OF THE IMPACTS OF PARKING
MANAGEMENT**

IN

KNOXVILLE, TENNESSEE

*A Thesis
Presented for the*

**Master of Science in Planning
Degree**

The University of Tennessee, Knoxville

Kimberly K. Henry

December, 1994

DEDICATION

This thesis is dedicated to my parents

Ms. Nancie L. Henry

&

Mr. Robert L. Henry, III

whose love and support have seen me through
the best and the worst of times.

ACKNOWLEDGMENTS

I would like to thank my major professor, Mr. James A. Spencer for his guidance and insight. I would also like to thank Dr. Fred Wegman, a committee member extraordinaire. Thanks also to the rest of my committee, and to Nancy Loftis. Will, I could not have done it without you. Special thanks to all my classmates, friends, and family who have supported me through this masters degree ordeal. Very special thanks to my "counters" Jerry Roberson, Jennifer Parker, and Devin Doyle.

ABSTRACT

This thesis proposes the use of parking management tactics for the Central Business District of the City of Knoxville, Tennessee. An incremental logit model is used to assess the impacts of parking management tactics on a sample of home based work trips. The model used showed that parking management tactics can produce reductions in vehicle trips for the sample.

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ABBREVIATIONS

Clean Air Act Amendments of 1990	CAAA
Central Business District	CBD
Central Business Improvement District	CBID
Federal Highway Administration	FHWA
Federal Transit Administration	FTA
Home Based Work	HBW
High Occupancy Vehicle	HOV
Intermodal Surface Transportation Efficiency Act of 1991	ISTEA
Measure of Effectiveness	MOE
Metropolitan Planning Commission	MPC
Metropolitan Planning Organization	MPO
"Downtown Knoxville Parking Study"	<i>Parking Study</i>
State Implementation Plan	SIP
Single Occupant Vehicle	SOV
Transportation Demand Management	TDM
The Downtown Organization	TDO
Tennessee Department of Transportation	TDOT
Transportation Improvement Plan	TIP
Transportation Management Association	TMA
Transportation Systems Management	TSM
U.S. Department of Transportation	USDOT
Vehicle Miles of Travel	VMT

CHAPTER 1 INTRODUCTION

TRANSPORTATION PLANNING

Transportation planning has been an integral part of comprehensive urban planning almost since the passage of the 1956 Interstate Highway Act. This act, along with the establishment of the Highway Trust Fund, provided for the construction of the multi-lane high speed, limited access interstate system. True transportation planning was codified in 1962 when the mechanics of the urban transportation planning process, involving continuous, comprehensive cooperation among state and local officials were spelled out in the Federal Aid Highway Act. During the fifties and sixties, transportation planning concentrated on facility construction.

Highway Acts in the early 1970's promoted regional transportation planning. In 1975, the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (now the Federal Transit Administration-FTA) charged the Metropolitan Planning Organizations (MPO's) with preparing multi-year plans and annual work programs that specified all expected transportation projects in the MPO's region. Funding for these projects became contingent upon preparation of these plans (Wiener 1992). This new attitude was in recognition of the fact that building more roads was not the only answer to an area's transportation needs. Transportation Systems Management (TSM) was the

terminology used to describe the approach adopted at this time that promoted and emphasized the use of existing transportation systems and facilities.

TRANSPORTATION DEMAND MANAGEMENT

With the passage of the Clean Air Act Amendment (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, a more demand side, user oriented approach has been mandated. According to Donald H. Camph, in a paper presented to the National Association of Regional Councils, the necessary transportation planning viewpoint "...holds that the ISTEA has given a new impetus to an holistic approach to managing existing transportation resources and planning for the future (Camph 1992, I-3)."

Transportation Demand Management (TDM) is the terminology used to describe activities that are concentrated on reducing transportation demand. The intent of TDM is to "...maximize the people-moving capability of the transportation system by increasing the number of persons in a vehicle, or by influencing the time of, or need to, travel (Comsis 1993, I-1)." There are several different programs and policies that are normally referred to as TDM techniques. Various authors, including Jeffery Zupan (Zupan 1992) have described these techniques. Generally, the techniques effect either the work place or the time or cost associated with the work trip. Work place changes include land use and zoning that attempt to insure densities which can support

public transit or High Occupancy Vehicle usage and encourage mixed-use developments. Time or cost changes include alternative work schedules to reduce peak-hour usage of transportation facilities, ridesharing to increase average vehicle occupancy, preferential high occupancy vehicle treatment that facilitates the use of rideshare vehicles, transit subsidies to encourage the use of transit, congestion pricing that charges a users fee to those commuters desiring to use a portion of congested roadway, and parking management that reduces the incentive to provide free or unrealistically priced parking.

Kenneth Orski reports that there are three components of an effective demand management program (Orski 1990): offering a wide range of TDM choices to those affected commuters; encouraging the use of these alternatives by providing incentives; and insuring private sector involvement in TDM activities. Orski goes on to suggest that "...A particularly effective form of a financial incentive is a 'transportation allowance' coupled with elimination of free parking (Orski 1990, 489)."

PARKING MANAGEMENT

Parking management is a TDM technique that involves various stakeholders and includes a variety of tactics. The intent of a parking management program is to decrease the volume of vehicle trips by increasing average vehicle occupancy. The volume of person trips should not decrease.

In a report published by the US Department of Transportation (USDOT) and the FHWA, a parking management tactic has been defined as (Di Renzo, Cima, and Barber 1979, II-1):

...an action taken to alter the supply, operation, and/or parking demand of a jurisdiction's parking system to further the attainment of local transportation, economic, environmental, and other applicable objectives

A parking management program can involve the use of a variety of parking management tactics in order to accomplish the objective of reducing vehicle trips. Parking management programs can include other programs such as marketing, enforcement, fringe parking, park and ride lots, residential parking permits, or shopper reimbursement.

There are a variety of tactics that are included in parking management. In general, parking management tactics regulate either the supply or cost of available parking in an area. Parking management tactics are presented in Table 1.

Some tactics (especially those used in areas where employers provide parking) require the employer to implement the parking management action. Other tactics involve a public agency taking the responsibility for implementing the parking management action. No matter what approach is used, the intent is the same--to modify commuter behavior via incentives/disincentives in order to reduce vehicle trips into the parking management program area.

TABLE 1: TYPES OF PARKING MANAGEMENT TACTICS SUGGESTED BY THE FHWA

ON-STREET PARKING	OFF-STREET PARKING	FRINGE & CORRIDOR PARKING	PRICING	ENFORCEMENT & ADJUDICATION	MARKETING
Add or Remove Spaces	Expand or Restrict	Fringe	Parking Rates:	Enforcement	Advertising
Change Mix of Short & long-term Parking	Off-Street Supply:	Parking	•Increase:	•Non-Police Enforcement	•Brochures
	•zoning:		Parking price,	Personnel	•Maps
	Max & min requirements,	Park & Ride	Parking rate	•Ticketing	•Media
Parking Restrictions:	Joint use	Parking	revision, Parking tax, Parking	•Towing	Convenience Program
•Peak	•constrain normal growth in supply:	Carpool/Vanpool	surcharge	•Booting	
•Off-Peak	•Ceiling on number of spaces in area,	Parking	•Decrease	Adjudication	
•Alternate Side by Time or Day	Reduced min parking requirements,		•Free Parking	•Administration	
•Prohibitions Before Certain Hours	Restrict principal use parking facilities		•Differential Pricing:	•Judicial	
Residential Parking Permit Program	•construct new lots or garages		Short-term vs. long-term rate, Pool discounts, Vehicle size discounts, Geographic differential rates, Monthly contract rates		
Preferential Parking:	Change Mix of Short & Long-term Parking		Merchant Shopper Discounts:		
•Meters	Restrict Parking During Selected Hours		•Stamp Programs		
•Stickers	Preferential Parking		•Token Programs		
Loading Zone Regulations:	•Pools		Employer Parking Subsidies		
•Bus	•Disabled		•Reduce Subsidy		
•Taxi	•Small Vehicle		•Transit Subsidy		
•Delivery					
•Diplomat					

Source: Adapted from DOT-FHWA, Study of Parking Management Tactics, Volume II: Overview and Case Studies (Springfield, VA:National Technical Information Service, 1979), II.4.

THESIS INCENTIVE

The reason for reducing vehicle trips varies among municipalities. Urban areas that are classified as non-conforming for air quality standards will benefit by a reduction in the amount of vehicle miles of travel (VMT) generated. Municipalities may wish to allocate less funds towards the construction of new parking or other transportation facilities. Other municipalities may wish to see an increase in transit usage that will help decrease the amount of local operating subsidy to transit. Additionally, municipalities may wish to reduce vehicle trips in order to reduce energy consumption.

Each of these reasons for reducing transportation demand are reinforced by Federal legislation. The two pieces of legislation that are having the most influence on transportation planning were mentioned earlier in the paper. Below, the impact of these Acts is more fully developed.

According to the Federal Highway Administration pamphlet *A Summary: Transportation Programs and Provisions of the Clean Air Act Amendment of 1990* (FHWA 1992), areas are required to attain and maintain the National Ambient Air Quality Standards for ozone (O_3), carbon monoxide (CO), and small particulate matter (PM_{10}). Any plans by areas deemed as non-attainment for one of these pollutants must conform with the State Implementation Plan (SIP). Additionally, a more integrated approach to transportation and air quality planning must be undertaken. If an area does not at least have an acceptable plan in

place, highway funding may be affected. Planning for air quality attainment can include a parking management program.

In a pamphlet from the USDOT, another important legislative action is discussed. In *A Summary: Intermodal Surface Transportation Efficiency Act of 1991* (USDOT 1992), the new attitude of the Federal government towards funding of new transportation projects, transit, and alternative modes is discussed. The purpose of the Act is summarized as being:

"...to develop a National Intermodal Transportation System that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner."

The emphasis of the ISTEA is obviously on increasing the efficiency and productivity of the existing transportation infrastructure. Therefore, municipalities must be willing to devise strategies that complement this attitude. Again, one of the planning tools that can be used to facilitate the more effective use of existing transportation facilities is parking management.

This thesis was written in order to test the idea of using parking management in the Knoxville Central Business District (CBD). As a mid-sized city with expectation of growth and prosperity, Knoxville will eventually have to deal with the decision of whether or not to expend capital funds in order to increase the parking supply in

the CBD. Also, due to Knoxville maintenance status for O_3 , steps will need to be taken in order to prevent a further degradation of the city's air quality. By using planning analyses now, the need to expend capital funds may be altered and further air quality problems may be avoided. This thesis will determine the applicability of Parking Management as a planning tool in the Knoxville CBD.

THESIS ORGANIZATION

This thesis is organized to move from general concepts to more detailed and specific concepts. The Chapters of the thesis and general contents are as follows.

The Introduction Chapter is followed by the Literature Review. This chapter presents the thoughts and ideas on parking management from the viewpoint of several different transportation professionals.

The literature review prepares the reader for the chapters that follow. In the Research Question and Methodology Chapter the aspects of parking management being studied are discussed. In addition, information and data collection needs are discussed. Also, the Logit model employed in this thesis to evaluate the impact of parking management tactics is described.

In the Case Study chapter, the information and data pertinent to the Knoxville CBD is presented. Also presented in this chapter are the alternatives generated by application of the Logit model.

The final chapter of the thesis synthesizes the information presented in the previous chapters and discusses the general applicability of this thesis to other similar areas. Areas of future research are also discussed in the final chapter.

CHAPTER 2 LITERATURE REVIEW

Transportation Demand Management (TDM) is the terminology used to describe activities that are concentrated on reducing transportation demand. The intent of TDM is to "...maximize the people-moving capability of the transportation system by increasing the number of persons in a vehicle, or by influencing the time of, or need to, travel (Comsis 1993, I-1)." As indicated in the introduction, Parking Management is a TDM technique. The literature concerning TDM in general and Parking Management specifically will be discussed in this chapter.

GENERAL TRANSPORTATION DEMAND MANAGEMENT

In a paper presented by Reid Ewing entitled "TDM, Growth Management, & the Other Four Out of Five Trips" (Ewing 1993), general information concerning TDM programs is presented. According to the author, the three challenges of TDM in the future include reproducing exemplary programs, involving small employers, and including non-work trips in TDM management programs.

The Ewing paper reanalyzes several TDM studies to determine their effectiveness and potential for implementation in Florida. The author

summarizes the effectiveness of several ridesharing programs. Where parking for alternative modes is subsidized, daily trip reductions range from 35% for the Commuter Computer in Los Angeles, California to a low of 4% at Chevron in Concord California.

Other papers that present general TDM strategies and programs are summarized below. References to parking management are noted.

Thomas J. Higgins presents the results of a study concerning employer based TDM policies in suburban settings in the paper "Demand Management in Suburban Settings: Effectiveness and Policy Considerations (Higgins 1990)." The author divides TDM strategies into two categories--Transportation Systems Management (TSM) and Parking Management. Several programs are analyzed in the case study section of the paper. Higgins found that aggressive parking pricing strategies were necessary for effectiveness. Decreases in the drive alone rate after increases in parking pricing ranged from 12% to 40%. The paper deals mainly with mandated programs.

Kathleen L. Snow presents a program designed to provide TDM options to the employees of a university and a medical institution in an urban activity center in Seattle, WA in the paper "First Hill Action Plan: A Unique Public/Private Approach to Transportation Demand Management (Snow 1989)." The setting in which this plan was implemented is important due to the fact that limited parking and high costs are prevalent. Service from the areas' park and ride lots is a part of the program.

Before the program was implemented, employers had to expend private dollars to provide express services and park and ride lots for

their employees. The institutions formed a Transportation Management Association (TMA) to share costs of a new and improved system. Parking credits are allowed for each participating employee. These can be used once monthly to facilitate ease of trip planning.

Papers that present methodology associated with survey work and TDM are presented in "Suburban Activity Center TDM Market Research Study (Valdez et.al. 1988)" and "Developing Transportation Demand Management Packages Using Transportation surveys: Case Study (Black et.al. 1992)." Objectives of the study, methodology behind the survey, and the results of the study are presented. Parking management options are discussed in both papers.

In the paper "Market Research Evaluation of Actions to Reduce Suburban Traffic Congestion: Commuter Travel Behavior and Response to Demand Reduction Actions" (Koppleman, Bhat, and Schoffer 1993) the authors present the results of an analysis of mode share trends and survey results for suburban Chicago which utilized a model to evaluate mode choice and stated intentions. Information for this analysis was obtained from an attitudinal survey and from travel diaries. Their findings indicate that decreases in solo driving can be accomplished through a combination of ridesharing incentives and significant increases in parking pricing when applied on an area wide basis.

Jeffery M. Zupan presents an overview of different TDM options that municipalities may choose from in a paper entitled "Transportation Demand Management: A Cautious Look" (Zupan 1992). These options include alternative work schedules, ridesharing, parking management, preferential treatment for high-occupancy vehicles, congestion pricing,

and land use and zoning. The author makes two important conclusions: that development clustering and provision of incentives to relocate existing development are necessary to make alternatives to the single occupant vehicle viable, and that the will to "...raise the price [of driving alone] to attack air pollution, energy shortages, and traffic congestion has been absent (p. 8)."

In the section on parking management, Zupan points out that "...employers often pay the cost [of parking], which is seen as a business tax deduction by employers and a tax-free fringe benefit by the employee (p. 3)." Preferential parking as well as higher cost for Single Occupant Vehicles (SOV's) and transportation benefit payments to be used for newly instituted parking costs are two strategies that the author suggests to decrease parking demand. Another, more effective method, is to limit the amount of parking spaces that employers can provide. For any of the above mentioned strategies to work, institutional changes are required. The tax benefits of employer paid parking will have to be reviewed. Additionally, zoning ordinances that require four spaces for each one-thousand square feet of floor area are out of date and need to be modified.

Zupan's paper mentions actions that would require cooperation between several different stakeholders. In Kenneth C. Orski's paper "Can Management of Transportation Demand Help Solve Our Growing Traffic Congestion and Air Pollution Problems? (Orski 1990)" a description is given of the various requirements necessary to manage demand. The author states that provisions for amenities (such as guaranteed ride home) and incentives (such as "transportation allowances") are

necessary to encourage drive-alones to take advantage of the provided alternatives and that private sector involvement is a necessity. A breakdown is given of percentage reductions achieved by several demand management incentive programs. When parking charges are nominal, a 2% reduction was noticed. When parking charges were increased to market rates, a 12% reduction was noted. These incentives were provided in conjunction with other demand management incentives.

The types of programs used to generate private sector involvement include use on review type of arrangements, mandated involvement, and "carrot" approaches where the developer is offered reduced parking requirements or tax credits. The approach used in Montgomery County, Maryland involves the use of negotiated trip reduction agreements. In these, the adequacy of existing transportation infrastructure is determined before a developer gets approval for adding a new development. Even if the existing infrastructure proves to be inadequate, the developer can agree to implement trip reduction techniques in exchange for approval. The author points out that Montgomery County has a strong background in growth management and a planning commission that is committed to traffic mitigation.

The idea that local ordinances and perceptions can also play a role in the provision of free parking is explored in another paper. Case studies of ten cities are presented in a paper by Carolyn P. Flynn and Lawrence Jesse Glazer entitled "Ten Cities' Strategies for Transportation Demand Management (Flynn and Glazer 1989)." The cities included are: Seattle, Washington; Portland, Oregon; Montgomery, Alabama; Sacramento, California; Bellevue, Washington; Orlando,

Florida; Irvine, California; Dallas, Texas; Pleasanton, California; and Los Angeles, California. Each case study includes strategy descriptions and implementation issues, demographic and socioeconomic data, and each cities' experience to date with the strategy.

The authors stratify the strategies into seven categories based on the type of approach used. These categories include: Region wide rideshare agencies; developer requirements; transportation fees; incentive ordinances; Transportation Management Organizations; employer rideshare ordinances, and comprehensive TDM ordinances. The incentive ordinances category deals with parking specifically. Cities using strategies in this category have adopted ordinances or have policies that provide developers with the option of having on-site parking requirements reduced in exchange for adopting traffic mitigation actions. It is noted that of the four cities which have used an incentive ordinance are doing so with little success.

"Transportation Demand Management Planning, Development, and Implementation (Ferguson 1990)", by Erick Ferguson discusses the role of developers, employers, and others involved in the transportation field. How TDM policies can be implemented by each of these players is detailed. A discussion is included of regulations (Transportation Reduction Ordinances); Transportation Management Associations (TMA's), and contractual agreements between public and private entities. The need for cooperation amongst these entities is emphasized.

Parking management is discussed as a transportation strategy used to cause a shift in low occupancy modes to high occupancy modes. Ferguson refers to several sources when he comes to the conclusion that

parking management is the most effective TDM element but also one of the hardest to implement because of tax codes and the use of free parking as an employee recruiting incentive.

Many areas have adopted some type of TDM technique to combat congestion, meet air quality improvement requirements, or lessen the need for constructing additional transportation facilities. Kenneth Orski reports that there are three components of an effective demand management program (Orski 1990): offering a wide range of TDM choices to those affected commuters; encouraging the use of these alternatives by providing incentives; and insuring private sector involvement in TDM activities. Orski goes on to suggest that "...a particularly effective form of a financial incentive is a 'transportation allowance coupled with elimination of free parking (p. 489)." In any TDM or parking management program, the effectiveness must be measured.

Martin Wachs attacks the perception of how much the trip to work actually costs in a paper entitled "Policy Implications of Recent Behavioral Research in Transportation Demand Management (Wachs 1991)." In this paper, the idea that travel behavior can be altered by implementation of TDM policies is discussed. Studies pertaining to the attempt to offer incentives that decrease travel time and costs are explored. Other studies concerning variables such as comfort, convenience, and safety are also mentioned. The author suggests that although the relationship between the many variables effecting travel choice is complex and at times ambiguous, the insight gained by researching this area will prove to be useful to transportation policy makers.

Two of the most influential aspects of the extensive network of drive alone encouragements in the United States include low gasoline and parking prices. For the most part, drivers do not include the capital costs of driving (such as purchase price, insurance and maintenance) when figuring daily transportation cost. Only the "out-of-pocket costs (gas, parking, and tolls) are figured into the daily work trip. Wachs refers to several studies where parking management has been explored. In these, the consensus is that parking is predominantly free to employees and that increases in parking pricing can be a very effective incentive to behavioral change.

The paper, "Measures of Effectiveness for TDM (Glazer 1993)", presents a summary of the different "measures of effectiveness (MOE's)" used by transportation practitioners to evaluate TDM programs. The author presents a taxonomy of these MOE's that includes: (1) mode share, (2) vehicle occupancy rate, (3) vehicle trip reduction, (4) vehicle miles of travel reductions, and (5) level of service.

A description of each of the MOE's is followed by a discussion of the environments in which TDM is used including employer size and type of land use (urban, suburban, single tenant, etc.).

Techniques used to collect data about each of the MOE's include cordon counts, surveys, and roadside counts. The advantages and disadvantages of each MOE are also presented. A section concerning comparisons of dissimilar projects by using cost-benefit and cost-effectiveness analysis is also presented. The author suggests converting the results of the MOE's to dollars saved in order to compare dissimilar projects.

PARKING MANAGEMENT

Parking management is a TDM technique that is once again receiving much attention. There are a variety of policy actions that are included in parking management as was illustrated in the previous papers. Some of these are: employers subsidized parking for High Occupancy Vehicle (HOV) users, locating parking facilities farther away from employment sites, transit pass subsidies, and areawide parking taxes. The previous papers also show that some techniques (especially those used in areas where employers provide parking) require the employer to implement the parking management action. Other techniques involve a public agency taking the responsibility for implementing the parking management action. No matter what approach is used, the intent is the same--to modify commuter behavior via incentives/disincentives in order to reduce vehicle trips.

"Cashing Out Free Parking" (Shoup 1982) was written by Donald C. Shoup and concerns the problem of employer paid parking. A central question in this paper concerns "...what would be the aggregate effects of cashing out employer paid parking." Three studies dealing with how changing parking subsidies effect parking are presented.

The first study was conducted in 1969 in Los Angeles. In this study, two groups of workers are compared. One group pays market rates for parking. The other group parks free. Solo driving is higher over various characteristic stratifications when parking is free.

The second study was conducted in Ottawa, Canada in 1975. This study showed a drop in solo driving of 20% when free parking was eliminated.

The third study concerns the Shirley Highway express bus service. This 1972 study showed that the parking subsidy that some former bus riders were receiving was comparable to the cost of bus fare.

Shoup discusses some of the repercussions associated with the elimination of employer subsidized parking. If all free parking were eliminated, solo drivers would not necessarily switch to an alternative mode. On the contrary, reduction of demand would cause the market value of parking to decrease. Ending free parking would increase the price of parking for those who formerly parked free. However, those who had paid to park previously would enjoy the benefits of increased supply and lower market prices.

Other situations that could occur if free parking were eliminated include a decrease in traffic volume during peak hours due to fewer solo drivers or a decrease in transit use due to bus riders switching to carpooling because of the decreased market price of parking.

Shoup also discusses the impact of free parking on zoning. Zoning ordinances have required minimum numbers of parking spaces to meet the artificial demand created by employer subsidized parking.

There are also environmental benefits associated with the cessation of free parking. Higher prices for parking would cause fewer short work trips and cold starts thereby improving the air quality. Also, fewer trips would mean less fuel consumption.

In the next section of the paper, Shoup discusses the tax-exempt fringe benefit status of free parking. Free parking is not taxable. However, an employer provided subsidy of an alternative mode is taxable. The author suggests allowing a tax exemption for cash in lieu of free parking. The author suggests phasing in the cashing out of free parking until an acceptable level is reached between cost and benefits.

In the paper "Parking Subsidies and Travel Choices: Assessing the Evidence" (Wilson and Shoup 1990) by Richard Wilson and Donald Shoup, the authors begin by examining the costs associated with the work trip in Los Angeles. For those commuters who receive free parking, the cost is 90 cents--the cost of gas for an average round trip to downtown LA. For the commuter who pays to park, the cost is \$4.90--the cost of gas plus the cost to park. The authors intend to summarize previous studies and show how employer subsidized parking effects commuter mode choice.

Wilson and Shoup used three methods to measure the effects of parking subsidies in the various case studies. These three measures are: drive alone share for work trips, number of cars driven to work per 100 commuters, and parking price elasticity of demand for solo driving. The last measure shows the expected percentage change in solo driving given a one-percent increase in cost.

In general, the authors found that the elimination of employer paid parking reduces solo trips. Also, a greater reduction is gained from the elimination of free parking than from transit and/or rideshare subsidies where free parking is still provided. Table 2 shows the

results of five before/after and with/without studies. In Table 2, three measures of effectiveness are used to evaluate the case studies. "Solo Share" refers to the percentage decrease in share of commuters who drive to work alone.

Additional studies were summarized in the paper. In Seattle, Washington, lowering parking charges for carpools had little effect due to the already low parking prices. In Madison, Wisconsin, an a.m. peak surcharge did little to reduce solo driving, but did spread the peak out by causing commuters to drive to work at later or earlier times. subsidies are discussed.

In a survey conducted by the Commuter Computer, it was determined that firms with free parking generate a 77% solo share while firms without free parking generate a 52% solo share.

In another paper by Shoup and Wilson, "Employer-Paid Parking: The Problem and Proposed Solution (Shoup and Wilson 1990)" three topics are explored: the problem of employer provided parking subsidies, the solution of providing a cash substitute for the parking subsidy, and the possible consequences of providing this substitute. The data used is from recent research in downtown Los Angeles.

Shoup and Wilson found a high incidence of free or subsidized parking in downtown LA. Also determined was that the average daily parking subsidy of \$3.87 was almost twice the amount of the price of the gas it would take the average driver to consume to get to downtown LA (1.8 gallons consumed for the average 36 mile round trip times \$1/gallon = \$1.80).

TABLE 2: TRIP REDUCTION PERCENTAGES FOR SELECTED CASES

Case	Cost Change	Solo Share	Commuters/100 autos	Elasticity
Mid Wilshire Area Near CBD	+\$57.50	-83%	-43%	-0.71
Warner Center Suburban	+\$30.00	-49%	-32%	-0.31
Ottawa CBD	+\$23.00	-20%	-18%	-0.11
LA Civic Center CBD	+\$30.00	-44%	varies	-0.29
Century City Suburban	+\$30.00	-18%	-15%	-0.11

Source: Adapted from Richard W. Wilson and Donald C. Shoup, Parking Subsidies and Travel Choice: Assessing the Evidence (Molokai, Hawaii: 29th Annual Meeting of the Western Regional Science Association, 1990)

Note: The entries in the column headed "Commuters/100 autos" shows the percentage decrease in the relationship between the number of commuters for every 100 autos driven. Elasticity refers to the percentage change in the proportion of solo drivers that is due to a one percent change in parking pricing.

Two specific problems with employer paid parking are discussed. The first of these is that employer paid parking increases the solo driver rate. It is shown that a reduction in the solo driver mode share of between 18% and 81% was realized at five downtown Los Angeles sites after parking charges were introduced.

The second problem is that employers restrict the subsidy to parking costs. The employer does not pay for alternatives, even when the employee does not value the parking subsidy as much as the employer does. The practice of providing the subsidy whether or not the employee values it or not is privately and publicly wasteful. Paid parking subsidizes and the tax exemptions they enjoy mask the market effect of total transportation costs.

The authors explain that the strongest reason for employers to provide parking subsidies is tax related. Parking subsidies are excluded from the employees' income for taxable purposes. In addition, it is more "tax-efficient" for the employer to provide the tax free parking subsidy as a benefit rather than the taxable cash benefit. However, the authors are quick to point out the pitfalls associated with tampering with parking subsidies.

In the next section of the paper, the authors discuss how local public policy could be used to counteract free parking. A Los Angeles ordinance requires employers who provide free parking to their employees to also provide a \$15 transit pass in-lieu of the free parking if the employee so desires. Shoup and Wilson would like to see employees offered the fair market value of the parking subsidy in lieu of the free parking. The employees would now have the option of

receiving free parking, which is tax exempt, or the cash equivalent, which is viewed as taxable income. The employee would be better off because he or she now has options. This policy would even be considered somewhat progressive in consideration of taxation of the lowest income workers because the cash out would make up a larger portion of that employees income but would have the least amount of taxes taken out of it because of the lower tax bracket. The authors also point out that this type of policy would have a psychological affect on commuters. They would begin to realized that parking is not free and behave accordingly.

It is not inconceivable that an employer would offer an employee cash in lieu of the parking subsidy. However, tax laws strongly bias the employer towards providing the subsidy. This is even more of a problem in CBD's where transit is most readily available, congestion is the worst, and air quality is the worst.

There is an even stronger motive for the Federal government to take action to initiate the cash in lieu policy. Such a policy would increase tax revenues and decrease exemptions. A special rule is now part of the tax code that defines subsidized parking as a "working condition fringe" . Changing the federal tax code would eliminate the need for local ordinances. It would also generate significant revenue for federal and state governments.

Questions concerning definition of cash in lieu, where the employers will find the money for the cash in lieu payments, enforcement, elimination of the tax subsidy for free parking, and increased tax exemptions for poolers are discussed. The authors argue

that employees who do not drive (the supply of which is more elastic than those who do drive) are being discriminated against because they do not receive the same benefits as do their driving counterparts.

A multinomial logit model is used to evaluate the effects of a required cash out of employer paid parking in downtown LA. The results of cashing out the parking subsidy reduces the drive alone rate by 30%. The authors conclude the paper by recommending that employers subsidize people not cars.

MODELING FOR TRANSPORTATION DEMAND MANAGEMENT EVALUATION

Modeling is often used to explore the possible impacts of various transportation planning activities. In the following papers, modeling is used to evaluate TDM programs that include parking management.

A project performed in Pleasanton, CA to evaluate the cost-effectiveness of employer-based TDM measures is evaluated in the paper "TDM Cost Effectiveness Model for Suburban Employers (Dagang 1993)", by Deborah A. Dagang. The focus of the model developed in Pleasanton is on cost effectiveness in a suburban setting.

A model is used to evaluate the cost-effectiveness of various TDM techniques. In the model, transportation environments are used to describe the availability and characteristics of transportation services that would support TDM. Employer based TDM measures are defined and evaluated. These include three parking measures: reduction

of Employer-subsidized parking, preferential parking for carpools and vanpools, and reduction of parking supply. Direct monetary incentives for use of alternative transportation and transportation allowances were also evaluated.

The data collection methods for input into the model include a literature review, an employer survey, and a review of existing database. The cost-effectiveness methodology for developing the model involved using estimates from existing literature on successful TDM measures. This was done because little direct employer information existed. Calculations employer-subsidized parking and transportation allowances were performed.

The results of a sample run of the model are presented. The author concludes that the most cost effective TDM measure is the reduction of employer subsidized parking. Obviously, if an employer begins charging for parking a revenue will be made. But even when this is accounted for, elimination of free parking is still the most effective action. Of course, the political ability to implement this measure is questioned.

The evaluation of TDM strategies conducted by The Toledo Metropolitan Area Council of Governments is presented in the paper "Evaluation of Demand-Management Strategies for Toledo's Year 2100 Transportation Plan (Decorla-Souza and Gupta 1989)", by Patrick DeCorla-Souza and Jiwan D. Gupta. Future travel demand was simulated for the year 2101. Three extreme case alternative strategies were modeled as well as a traditional strategy. In the first three strategies, parking pricing was used to increase the cost of driving to

work. The impact of the three alternative TDM strategies was simulated using the TMACOG's computerized travel model's. One of the areas discussed is the elimination of tax-based incentives.

An economic efficiency analysis was also performed for each alternative. Only escapable costs (discretionary) were considered. These included: highway user costs, highway facility costs, parking costs, transit costs, and employer/agency costs. Five other performance indicators (each with various MOE's) were evaluated including transit viability, economic development potential, safety, social benefits, and environmental benefits.

In the paper "Factors Affecting Transportation Demand Management Program Effectiveness at 6 San Francisco Medical Institutions (Dowling, Feltham, and Wycko 1991)", the focus is on TDM effectiveness in the context of the unique atmosphere of major medical institutions.

Three factors are weighed to determine TDM effectiveness, including parking management, promotional efforts, and the surrounding environment. A quantitative approach is taken to determine the effects of these three factors. A linear regression model was then used to forecast modal choice using on-site parking costs as the primary factor. A description of the survey design, including characteristics of the sites, quantification of these characteristics, and the identification of what constitutes a successful TDM program are presented. This is followed by a description of the six San Francisco medical institutions involved. The results of the survey are iterated along with the correlation among the factors under consideration. A discussion of the resulting linear model concludes the paper.

Parking is limited at all of the sites, but free near-site parking is available. It was found that on-site parking costs were the most highly correlated factor affecting employee automobile use. The linear regression model developed using the correlation analysis predicted that a 1% decrease in the drive alone rate could be achieved for each \$8 increase in monthly parking costs. Off-site parking restrictions and transit service improvements were also necessary.

FEDERALLY SPONSORED DOCUMENTATION

Most of the publications reviewed in this section of the literature review are research projects sponsored by the USDOT and the FHWA.

In the first document reviewed for this thesis, the emphasis is on local zoning ordinances and how the off-street parking requirements contained in them affect TSM activities. The document was written in 1983 and is entitled "Model Parking Code Provisions to Encourage Ridesharing and Transit Use (Smith and TenHoor 1983)."

Most of the Model Parking Code document deals with using zoning to foster public/private partnerships which are intended to make better use of the transportation system. In the document, there is a discussion concerning cost savings and benefits of reducing or eliminating minimum parking requirements from local ordinances. Also, the necessary components of a TSM program that compliments the parking

management options under consideration is given. The necessary components include: validity, attractiveness to the private sector, legality, flexibility, simplicity, and protection of the public interest. Parking management techniques that are available to municipalities include maximum parking requirements, fringe parking, and shared use lots. An example of a model code is presented at the conclusion of the paper.

In 1979 the FHWA published a series of reports prepared by John F. Di Renzo, Bart Cima, and Edward Barber of Peat, Marwick, Mitchell, and Company (DiRenzo, Cima, and Barber 1979). The three volumes in this series were entitled Study of Parking Management Tactics Volume I: Overview, Volume II: Overview and Case Studies, and Volume III: Reference Guide. Volumes II and III were reviewed for this thesis.

Volume II of the Study of Parking Management Tactics series provides an extensive overview of the state of the art in parking management tactics. The parking management tactics reviewed include those for on-street and off-street facilities. Case studies from the late 1970's are also presented.

Volume III of the Study of Parking Management Tactics series reiterates the finding of the previous volume but also supplies planning and implementation guides for the parking management tactics previously discussed.

K.T Analytics prepared a report on Parking Pricing for a USDOT/Federal Transit Administration (FTA) series of TDM Status Reports in August of 1992 (K.T. Analytics, Inc. 1992). In this report "TDM

Status Report Parking Pricing", four subsections deal with areas of concern in parking management.

The first subsection describes the approaches that can be used by governments or by the private sector. Government approaches include: imposition of fees or surcharges, preferential pricing for HOV's, parking provider taxes, regional regulations, requiring trip reductions by using parking management as a prerequisite to funding. Private approaches include: cash out subsidies, removing discounts, instituting preferential parking without government regulation, and management and enforcement of parking.

Examples of areas that have tried parking management are given. These include Madison, Wisconsin (peak period surcharge), Seattle, Washington (discounted carpool parking and developer agreements), San Francisco, California (parking tax and developer agreements), Bellevue, Washington (travel allowances, imposition of parking pricing, subsidized carpool parking, and management for prevention of parking in shopping areas), Los Angeles, California (travel allowances and imposition of parking pricing), and Montgomery County, Maryland (discontinuation of monthly discounts).

The report states that two issues are influential on whether or not parking pricing will be effective. These include current cost and attractiveness of alternatives. Other issues of concern include: proportion of employer subsidized parkers, availability of viable alternatives, and uncontrolled parking supply proximity. Several examples of reductions in the solo driver share are discussed in the K. T. Analytics report. Of these, the lowest reported decline was 12%.

Another aspect of parking pricing discussed in the K. T. Analytics report is the potential for commuters to avoid the change in pricing. Several examples are given where commuters have changed there parking location or time, or switched from transit to carpools. In several of these examples, substantial declines in solo driving rate are reported. Implementation issues are next discussed. The report suggests that public garages where pricing is below market rates are good candidates for parking pricing changes. These changes will be especially applicable in areas where public parking makes up a high percentage of the overall parking supply, transit is available, and the potential for spill over is low. Other strategies include reversal of monthly pricing discounts via regulation or negotiated agreements and travel allowances (where the employee is given an allowance to use on alternative transportation such as transit) or cash outs (where the employee is provide with the option to receive the cash equivalent of the employer provided parking space).

Planning and evaluation concerns for the zone under consideration include: through traffic proportion, supply and usage of parking, nearby parking supply, differences between public and private parking supply and rates, employer subsidization, alternatives supply, regulatory environment, and local power over the private providers.

Public sector rate hikes, if implemented, need to be accompanied by a review of the following: destination of increased revenues and the impact on shoppers, adjacent area, and the low income worker. Private sector pricing changes may be more difficult to implement. Approaches to consider include changes in the tax treatment of

providers that allow monthly or early bird discounts, negotiating with employers to provide cash outs, parking taxes, and ordinances.

Municipalities must also be prepared to deal with the cost of implementation and enforcement. What will be done with the increased revenue is another issue. Monitoring and evaluation must also be considered.

In another TDM Status Report by K. T. Analytics for the USDOT and the FTA entitled "TDM Status Report Transportation Allowances", transportation allowances are discussed (K.T. Analytics 1992b). Transportation allowances are used to increase the choices of commuters by increasing the attractiveness of alternatives to driving alone. Approaches covered under the topic of transportation allowances include transit passes, vanpool fare passes, parking allowances or free parking for HOV's, and general travel allowances. Several areas have experimented with non-traditional allowance programs. These are covered in the report.

The most successful of the transportation allowance approaches is the introduction of the general travel allowances. Under this program, employees are given an allowance to be spent on transportation each month. This money is taxable income if kept, but treated as non-taxable fringe if used for employer provided parking.

The tax consequences and acceptance by employers and employees is discussed. In general, acceptance of transportation allowance programs has been slow in coming. Part of the reason for this involves the tax status of transportation allowances. The IRS views transportation allowances as taxable income while the provision of free parking is

seen as a non-taxable fringe benefit. Transit passes and vanpool subsidies are tax exempt up to a certain amount each month [this amount has increased from \$21 to \$60 per month since publication of the K.T. Analytics document].

The cost of implementing the program can also be a deterrent to employers. However, the report states that after initial start up cost, the cost of running the program becomes negligible. In most cases, the cost saving of not paying to lease spaces or the money generated by charging to park in previously free spaces makes up for the cost of the allowance.

The authors suggest that the simpler forms of the transportation allowance programs are the most effective. Also, parking pricing changes must accompany the transportation allowances.

In a compilation report entitled Proceedings of the Commuter Parking Symposium (USDOT 1990) white papers, panel discussions, and parking program examples are presented. The topics covered in these papers were: Federal Policy, Elasticity, Local Tax, Leasing, Zoning, and Employer Incentives. The purpose of the symposium and the publication of the compilation report is to encourage policy initiatives, innovation in the parking management field, encourage demonstration projects, and attempt to influence needed changes in Federal policy.

The FHWA and the FTA have begun a series of reports on TDM. The report Overview of Travel Demand Management Measures (Comsis et. al. 1994) notes that unrestricted parking is detrimental to any type of TDM program. A process for implementing A TDM program is given and it is

noted that there are four basic requirements for successful implementation: commitment, constituency, coordination, and continuity.

The first of the reports on TDM was Evaluation of Travel Demand Management Measures to Relieve Congestion (Comsis et.al. 1990). The report looks at a variety of TDM programs across the country and evaluates those programs in quantitative terms. It is noted that traffic patterns are expected to worsen in the future and that funding for construction of new facilities and space for the new facilities is limited.

The second report on TDM was Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience (Comsis et.al. 1993) This report provides an overview of various TDM techniques and strategies. Parking supply and pricing management is covered in a subsection of the incentives and disincentives section.

The report begins with a discussion of the various actors involved in parking management and the roles that they play. The public sector sets codes and ordinances concerning parking, regulates the amount of off-street and on-street parking supply, and controls the rates of private providers via taxes. The federal government sets policy, specifically those concerning tax treatment. The private sector must follow the variations in ordinances for particular land uses and provides parking.

The report divides parking management into two categories: pricing strategies and supply management. Some of the approaches under pricing include the imposition of increased fees for solo drivers or

long term parkers in public facilities, price breaks for poolers, taxation of providers, regulations that increase costs, and, at the state level, trip reduction programs. Supply management includes zoning, codes, on-street controls, and limits on new parking supplies.

The Comsis report reviewed reiterates many of the lessons learned from the other literature reviewed for this thesis. Primarily, the issues of concern are

- *Alternative availability
- *Uncontrolled parking availability
- *Usage rate for public facilities where control is easier
- *Parking cost
- *Developer, lender, and other private sector actor involvement

Implementation issues including cost, distribution of new revenues, and the players whose involvement is necessary are discussed. The report suggests that a thorough inventory of existing conditions similar to the one in the K.T. Analytics Parking Pricing report be conducted in order to assess market conditions and possible responses.

Several case studies are presented in the report. It is apparent from reviewing the TDM case studies that parking management is an integral part of the successful programs.

SUMMARY OF SELECTED CASE STUDIES

The case studies presented below were chosen for their potential applicability to the parking management tactics that can be applied in the Knoxville CBD and for their compatibility in reporting reductions. Additionally, an attempt was made to select case studies that showed parking management tactics being applied on an areawide basis as opposed to single employer applications.

Parking Cost Manipulation

Much of the literature reviewed for this thesis involved using general TDM tactics to alleviate transportation problems. As was mentioned in the previous section, it is usually more affective to use a combination of tactics to achieve the desired results as opposed to using only single tactics. However, two of the publications that were reviewed did provide examples of parking management tactics deployed singly. A summary of these articles is provided below.

Wilson & Shoup, 1990

"Parking Subsidies and Travel choices: Assessing the Evidence"

Shoup & Wilson, 1991

"Employer-Paid Parking: The Problem and Proposed Solution"

Mid-Wilshire, near CBD, single employer

Elimination of parking subsidy decreased SOV Trips by 83%

Civic Center, CBD location, Federal and County Government Employees

Elimination of parking subsidy decreased SOV Trips by 44%
Century City, Office Park, private employers

Elimination of parking subsidy decreased SOV Trips by 18%
Ottawa, Canada, CBD, Federal government employees

Elimination of parking subsidy decreased SOV Trips by 20%

Combination of Parking Management Tactics Including Cost

Publications that provide case studies where parking cost manipulation, although the primary change, is accompanied by other tactics are reviewed below. The second publication also includes information that defines the limits of changes in the attributes under review.

Ewing, 1993

"TDM, Growth Management, and the Other Four Out of Five Trips"

Silver Springs, MD, CBD

Paid Parking for SOV's

Reduction in cost for Carpools

Free parking for Vanpools

Transit Subsidies

Other TDM Tactics

14% Reduction in Trips

Bellevue, WA, Corridor Area

Bus Passes

Preferential Parking

Free Vanpool service initially

Other TDM Tactics

up to a 7% Reduction in Trips

Los Angeles Region

Preferential Parking

Transit Passes

Other TDM Tactics

up to 7% Reduction in Trips

in AM

Portland Metropolitan Area

Discount Carpool Parking Downtown

Other TDM Tactics

3% Reduction in Trips

U.S. Department of Transportation

Implementing Effective Travel Demand Management Measures:

Inventory of Measures and Synthesis of Experience

City of Chicago

Increase in Parking Prices at City Lots produced a 35% decrease in cars parked in those lots.

Ottawa, Canada

Elimination of Parking Subsidy for government employees produced a 21% decrease in trips.

Single Employers that Eliminated Subsidies, Restricted and/or Reserved
Parking

Travelers--decrease of 47% in trips

Hartford Steam Boiler--Decrease of 26.5% in trips

San Diego Trust and Savings--Decrease of 22.7% in trips

TransAmerica--Decrease of 20% in trips

ARCO--Decrease of 19.1% in trips

Synthesis

SOV surcharges of approximately \$3 teamed with HOV and Transit
subsidies can produce up to:

60% trip reductions in areas with low Average Vehicle
Occupancies

58% trip reductions in areas with medium Average Vehicle
Occupancies

54% trip reductions in areas with high Average Vehicle
Occupancies

Average Vehicle Occupancy = All person trips / number of private
vehicle trips

The case studies illustrate the idea that parking management can
produce reductions in the number of SOV trips. The magnitude of
reductions varies from single digit percentages to around 60%. Reasons
for this range of reductions include transit availability, support
activities, and initial vehicle occupancy in the area. Parking cost

reductions are an integral part of the more successful applications of TDM or Parking Management Tactics. Travel time was discussed in terms of the impact of changing out of vehicle time via preferential parking tactics. The reduction rates realized and the implementation issues experienced in other areas will be used to develop the Knoxville CBD case study.

CHAPTER 3 RESEARCH QUESTION AND METHODOLOGY

RESEARCH QUESTION

As discussed in the literature review, TDM and parking management are viewed as key elements in any plans to reduce vehicle trips. With the passage of the ISTEA in 1991, the "Climate Change Action Plan" proposed by President Clinton (which includes "cash out" programs) (Dougherty 1993), and the recent changes in the tax codes as reported in the February 7, 1994 issue of *Passenger Transport* that increase tax-free and tax-exempt transportation allowances from \$21 a month to \$60 a month, it appears that the Federal level participation in shaping transportation planning favors non-traditional strategies as acceptable and valuable planning tools that local municipalities can use to decrease vehicle trips. But is parking management the answer? More specifically, can local governments of medium sized communities where the emphasis of transportation planning has been on traditional methods (i.e. building more facilities) use parking management to alleviate current or anticipated transportation problems brought on by increasing vehicle trip rates?

In order to fully explore this question, a case study of the city of Knoxville's CBD Business Core has been conducted. Knoxville is the center of a Metropolitan Statistical Area (MSA) that has a 1990 population of 585,960 and a county population of 335,749 of which

261,720 is urban. (Tennessee Abstract, 1993). The CBD, with an estimated 17,000 employees (Corradino 1993), still has a high concentration of employment, although suburban activity centers and the Department of Energy plants in the exurban portions of the MSA are also significant employers. As is the case with many medium sized communities, Knoxville is experiencing increasing suburban sprawl. Low densities in the suburban areas and sparse population in the hinterlands makes it difficult (though not impossible) to arrange for higher occupancy vehicle travel. Thus, there is much reliance on the single occupant vehicle for all types of trips. Additionally, funding for alternative transportation planning strategies has been overshadowed by funding for highway improvements. However, recent changes in the availability of funding and the structure of that funding have made alternatives to highway improvements more attractive and in some instances a necessity. This changing attitude is reflected in the General Plan for the City of Knoxville that suggests, where possible, an emphasis on low cost solutions to traffic problems as opposed to new construction or capital acquisition (Metropolitan Planning Commission 1993). Considering the use of parking management now may lessen the need to expend capital funds in the future.

A "sketch planning" framework will be utilized to determine the impact of parking management in the CBD on vehicle trips. The procedures used will be applicable for any mid-sized community. The emphasis of this thesis is on reducing vehicle trips as evidenced by a reduction in the number of SOV's entering the parking management zone.

More remote or more expensive parking facilities are intended to encourage commuters to seek alternatives to driving alone.

In order to assess the potential for reducing vehicle trips via parking management tactics, a logit model will be employed to predict the reduction in vehicle trips caused by increases in certain transportation decision attributes. Modeling has been used since the mid 1950's to better understand the dynamics of urban transportation (Weiner 1992). The type of modeling in question can use the trip tables generated as part of the traditional four-step planning process. However, because of the emphasis on sketch planning in this thesis, a less data intensive approach will be utilized.

Because of the relative predictability of work trips, only those trips will be evaluated in this thesis. A sample of Home Based Work (HBW) vehicle trips will be drawn by counting the number of vehicles parked in long-term parking spaces in the CBD. This sample will be used in the estimation of the impacts of parking management tactics. Threshold values for the attributes being tested will be developed to establish an interval to which the attribute values will be confined. The percentage reduction in the vehicle trips produced by the model for the sample will be compared to information contained in the Metropolitan Planning Commission (MPC) "Downtown Knoxville Parking Study (MPC 1990)" concerning expected increases in the demand for long-term parking downtown. It is assumed that an increase in demand for long-term parking will be due to an increase in vehicle trips.

Specific questions that are addressed by this thesis include:

- (1) What parking management tactics are available, and
- (2) Can parking management, when tested using a logit model, be used to produce a decrease in vehicle trips in the sample that will counterbalance the expected increase in vehicle trips to the CBD?

METHODOLOGY

The case study of Knoxville's CBD was conducted in the following manner.

Existing Conditions

Existing conditions in the CBD were assessed in order to develop a picture of the current conditions in the CBD. Parking information was taken from an inventory of existing parking supply conducted for this thesis, interviews with lot owners /operators, and the Knoxville/Knox County Metropolitan Planning Commission's "Downtown Knoxville Parking Study (MPC 1990)" (This document will be referred to as *Parking Study*).

Mode shares for vehicle trips were obtained from the "1994 Vehicle Occupancy Study for Knoxville, Tennessee (Knoxville Commuter Pool 1994)." Transit information was taken from the "Site Selection &

Conceptual Design of Downtown Intermodal Transportation Center Technical Report (Corradino Group, 1993)" and K-Trans personnel. Other information concerning general conditions and planned changes in the CBD were obtained from MPC documents, interviews with MPC staff members, The Knoxville News Sentinel, and attendance of Central Business Improvement District (CBID) meetings.

Parking Demand

Current long-term parking demand was assessed by counting the number of vehicles utilizing long-term parking facilities in the CBD Business core and significant fringe parking areas shortly after the AM peak. Physical counts were performed at selected long-term parking facilities in the Business Core Area of the CBD. It is assumed that vehicles parked in these facilities at this time were there for long-term, work purposes. Therefore, they were considered as having been used for HBW trips.

A total vehicle count was arrived at by summing the totals for each facility. This total vehicle count was corrected to reflect seasonal impacts by applying Tennessee Department of Transportation (TDOT) correction factors for day of the week and month of the year. This correction will render the total vehicle count more representative of a typical work day's travel pattern. A comparison was made to the *Parking Study* to determine historical stability. Mode share percentages were taken from the "1994 Vehicle Occupancy Study" and from the 1993 survey conducted by the Corradino Group for the "Downtown Intermodal Transportation Center Study."

Vehicle and mass transit HBW person trips were added together to determine total HBW person trips. The sample of HBW person trips used in calculations in this thesis -- 7977 is 47% of the population of 17,000 CBD HBW person trips. This sample size is larger than the 10% sample size considered to be reasonable to make generalizations about populations (Champion 1981).

Projected parking demand was obtained from the *Parking Study*. The *Parking Study* predicts that there will be an increase in both long-term (primarily workers) and short-term (primarily shoppers and visitors) parking demand in the CBD over the next several years. For this thesis, the emphasis will be on long-term parking. This increase is predicted by projecting current land uses into the future and assuming square footage by land use type. Trip generation rates for each land use were established based on MPC staff experience and the experience of the consulting firm that developed the model (The RBA Group). Using the projected square footage and the trip generation rates, the *Parking Study* identified increases in parking demand for 5-year and 15-year horizons. It will be assumed that the reason for this increase in demand for parking will be due to an increase in vehicle trips and will therefore be referred to as an increase in vehicle trips. The increase in vehicle trips will be reported as a percentage in order to make comparisons to the sample of current vehicle trips. The increase in vehicle trips predicted by the *Parking Study* will be used as a benchmark to compare the potential decrease in vehicle trips predicted by the model.

Logit Model Application

An incremental logit model developed in a draft report by Barton-Aschman Associates, Inc. was used to assess the potential changes in modal shares and vehicle trips due to changes in the value of certain attributes that are relevant to travel mode preference. Logit models are often used for "...making probabilistic predictions of mode choice (Horowitz et.al. 1986)."

The probability that a certain mode will be chosen because of changes in the attribute values will be predicted by the logit model. Desirable qualities for a logit model include (Horowitz et.al. 1986):

- Choice probability is dependent on the deterministic components of the utilities of all available alternatives
- Probability of an alternative being chosen is determined by the increase or decrease in the deterministic component of the utility function
- Any number of alternatives can be accommodated
- Easily understood and applied

The logit model is given by:

$$P_i = \frac{e^{u_i}}{\sum_{i=1}^k e^{u_i}} \quad (2.1)$$

Where,

P_i = Probability of a commuter choosing a mode i

u_i = The utility function for mode i

The logit model states that the probability of a commuter choosing a certain mode of transportation can be explained by a mathematical relationship. This relationship is explained in the utility function. The utility function is normally divided into two portions: the deterministic or estimated portion and the random component (which is implied) or the portion that explains the amount of error between the estimated utility and the actual utility (Horowitz, 1986).

The deterministic portion of the utility function, u_i , is given by:

$$u_i = a_i + b_i \times IVTT_i + c_i \times OVTT_i + d_i \times COST_i \quad (2.2)$$

Where,

a_i = constant for each mode i

b_i , c_i , and d_i = coefficients for each attribute

$IVTT_i$ = In Vehicle Travel Time for mode i

$OVTT_i$ = Out of Vehicle Travel Time for mode i

$COST_i$ = Cost of travel for mode i

The utility function states that, for each mode, there is a certain amount of utility. The mode with the highest utility has the highest probability of being chosen.

The logit model can be used to show the affect of changes in policy that would affect the amount of utility that commuters expect to receive from certain modes of transportation. Travel time and cost are two areas of policy change that are important to commuters.

Changes in the value of these attributes of utility will be measured using the following formula that reflects the affect of incremental change on the standard logit model:

$$P'_{i'} = \frac{e^{\Delta u_i}}{\sum_{i=1}^k e^{\Delta u_i}} \quad (2.3)$$

Where,

P' = Revised probability of choosing mode i

Δu_i = Change in the utility function

Where the change in the utility function is represented as Δu_i , and is given by:

$$\Delta u_i = b_i x \Delta IVTT_i + c_i x \Delta OVTT_i + d_i x \Delta COST_i \quad (2.4)$$

Where,

b_i , c_i , and d_i = coefficients for each attribute

$\Delta IVTT$, $\Delta OVTT$, and $\Delta COST$ = changes in each attribute

In essence, the incremental logit model begins with base conditions and then pivots from those conditions. This is done by

varying the value of the attributes for each mode. For each unit increase in OVTT, IVTT, or COST, there will be a decrease in the probability that that mode is chosen. For example, if COST is increased for one mode, then the probability that a commuter will choose that mode is decreased. The amount of that decrease is determined by the value of the coefficient used in the utility function. The literature reviewed for this thesis did not indicate that IVTT could be manipulated by parking management tactics in order to produce reductions in vehicle trips. Therefore, only changes in the values for the attributes COST and OVTT will be evaluated in this thesis.

An important assumption about logit models is that the coefficients used in the model are transferable. The Barton-Aschman model was chosen for use in this thesis because the coefficients were developed using data from several cities nation wide and because the data requirements were consistent with the sketch planning methods being used in this thesis.

Changes in modal share will be determined for the following mode choice set:

- Drive Alone
- Carpool 2-person
- Carpool 3-person
- Carpool 4-person
- Carpool 5-person
- Vanpool 12-person
- Transit

Coefficients used in the model are:

$$b_i = -0.050 \quad (2.5)$$

$$c_i = -0.025 \quad (2.6)$$

$$d_i = \frac{1248 \times b_i}{\text{Avg.IncomexTVP}} \quad (2.7)$$

Where,

b_i = Default Coefficient for IVTT

c_i = Default Coefficient for OVTT

d_i = Coefficient for COST

1248 = Annual Income conversion factor

Avg. Income = Average Regional Income for the Knoxville

Area from the 1993 Tennessee Abstract.

TVP = Value of time percentage (DEFAULT = 0.25)

Alternative Generation

Alternatives showing revised mode shares caused by changes in each category (OVTT and COST) and a combination of the categories were generated. Threshold values were established for each attribute. The attribute values were only varied within the interval established by these thresholds.

Evaluation

Evaluation of the generated alternatives was accomplished by comparing the percentage reduction in the Drive Alone share and the subsequent percentage reduction in total HBW vehicle trips in the sample to the percentage increase in demand for long term parking in the CBD as predicted in the *Parking Study*. The feasibility of these alternatives is established by comparing this case study to the literature reviewed for this thesis.

CHAPTER 4 KNOXVILLE CBD CASE STUDY

The case study of Knoxville's CBD was conducted in the manner established in the Methodology section of Chapter 3.

EXISTING CONDITIONS

Existing conditions in the CBD were established for parking supply, mode shares, transit usage and availability, general conditions, and planned changes in the CBD.

Parking Supply Inventory

The *Parking Study*, conducted in 1990, counted 14,199 off-street parking spaces. The study area boundaries defined in the *Parking Study* also define the study area for this thesis. Figure 1 shows the study area boundaries for this thesis. The major boundaries of the CBD-- Interstate 40 to the north, the James White Parkway to the east, the Tennessee River to the south and Henley Street to the west--make further geographic expansion unlikely.

A planimetric map of the CBD was obtained from the City of Knoxville Engineering Department. Using this City map, the location of surface lots and garages throughout the CBD was determined. A visual inspection of the surface lots and garages was then undertaken during

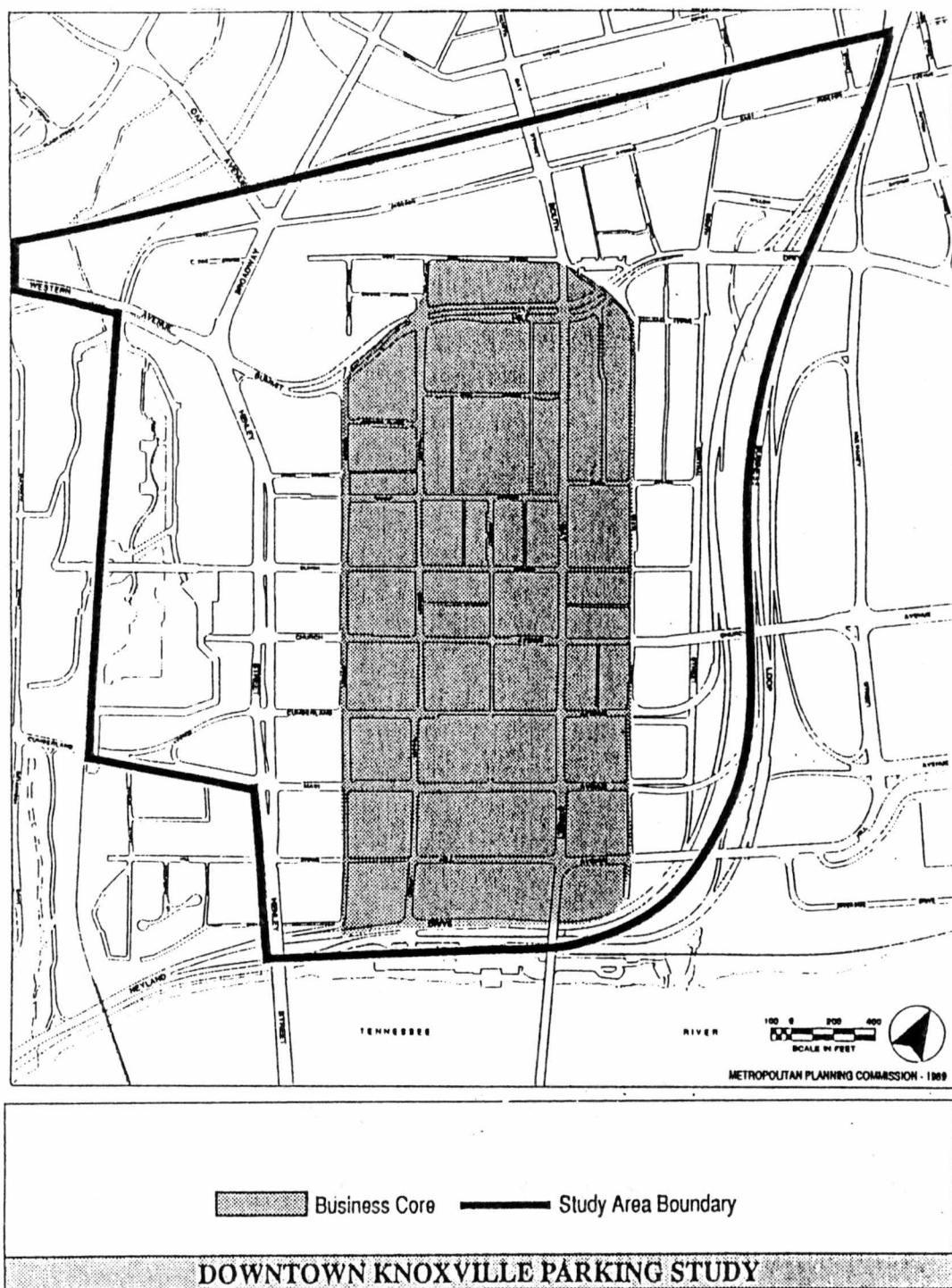


Figure 1: KNOXVILLE CBD

Source: Knoxville/Knox County Metropolitan Planning Commission.
 "Downtown Knoxville Parking Study." 1990.

the months of June and July of 1994. Visual inspection yielded several private operator lots and for private use only lots. The total number of spaces in the surface lots is 4677. Garages were identified in a similar manner and included nine private operator garages, three public garages, and three for private use only garages. The total number of spaces counted in garages in the CBD was 9763. The total number of spaces counted in the CBD was 14,440. Maps and tables showing the lot location, owner/operator, number of spaces available, and rates were created. These maps and tables are located in Appendix A.

Mode Share

Mode share for the city of Knoxville is collected each year by the Knoxville Commuter Pool for the Tennessee Department of Transportation and is contained in the "1994 Vehicle Occupancy Study for Knoxville Tennessee (KCP 1994)." City wide mode shares are based on the study of seven intersections in the city of Knoxville. The methodology of the study produces an Average Vehicle Occupancy (AVO) of +/- 5% of the actual AVO with a 95% level of confidence. The Vehicle Occupancy Study has been conducted annually since 1991. The survey is summarized in Table 3.

Transit Usage And Availability

Transit usage information was taken from the "Site Selection & Conceptual Design of Downtown Intermodal Transportation Center Technical Report (Corradino Group 1993)." A survey of transit riders was conducted for the Corradino Report. From the survey, it was

TABLE 3: MODE SHARE FOR KNOXVILLE, TENNESSEE

MODES							
	1	2	3	4	5+	VAN	TOTAL
VEHICLE MODE							
SHARE	0.786	0.178	0.026	0.006	0.002	0.002	1.0
AVERAGE VEHICLE OCCUPANCY	1.283						

Source: Knoxville Commuter Pool, Draft 1994 Vehicle Occupancy Study prepared for TDOT

determined that 20% of transit riders work downtown. This amounts to approximately 900 riders. According to the report, the employment for downtown is 17,000. This means that 5% of the downtown work force uses transit.

The Knoxville transit system has a CBD location for its transfer center. Additionally, K-Trans operates a Trolley service. One of these circulates from the Civic Coliseum Parking Garage, to the east of the CBD, through the Business Core Area of the CBD. A K-Trans Route Map and Trolley Map are enclosed in pockets as plates 1 and 2.

Plate 1: K-TRANS SYSTEM MAP



Plate 2: TROLLI

Downtown Trolleys

EFFECTIVE August 22, 1994

General Conditions

Various stakeholders concerned with parking in the CBD were determined. The Downtown Organization (TDO) was created to encourage implementation of the MPC's 1988 *Downtown Plan*. The Central Business Improvement District is a self taxing district within the CBD created to finance services that the government can not or will not. Other stakeholders include: the City, County, and Federal Governments; Allright Parking, Central Parking, EZ Park, and Republic Parking; CBD business owners and/or operators; and the CBD employees.

The Chamber of Commerce estimates the CBD work force at 22,179. This number includes some businesses that are not considered within the study area boundaries. Therefore, the Knoxville Commuter Pool estimate of 17,000 that was used in the Corradino Report will be used for work force size. The following list of large employers was obtained from the Knoxville Chamber of Commerce:

- Tennessee Valley Authority
- Knoxville News Sentinel
- First American Bank
- IBM
- Kimberly-Clark
- First Tennessee Bank
- Aluminum Company of America
- Knoxville Utilities Board
- City-County, State of Tennessee, and U.S. Governments

In addition to the Chamber of Commerce, other sources of information were contacted. These included lot operators, business people, and the MPC. Central Business Improvement District (CBID) meetings were attended and Knoxville News Sentinel articles were reviewed to obtain background and attitudinal information.

The zoning and planning documents concerning the CBD were reviewed. According to the zoning ordinance, The CBD is zoned as a unit as C-2. Uses permitted in this district are intended to promote the Central Business District as the primary "...metropolitan center for commercial, financial, professional, governmental, and cultural activities (p. 83)." Parking is considered a use on review. There are no off-street parking requirements.

Planned Changes

Planned changes in the CBD include: construction of the Federal Courthouse in the block bounded by Cumberland and Church Avenues and Gay and Market Streets; redevelopment on the north end of Gay Street just south of Summit Hill Drive; movement of additional University of Tennessee employees to the UT Conference Center on Henley Street; closing of Whittle Communications; completion of the Henley Street connector, Waterfront development that will include residential and commercial development, and a proposed Downtown Intermodal Transportation Center.

Land Uses

Land use in the CBD is primarily office with many governmental agencies represented. Additionally, commercial uses in the CBD include hotels, public facilities, restaurants, and some retail. Very little residential uses are located in the CBD. The *Parking Study* examined Retail, Restaurant, Hotel/Motel, Institutional (Schools, Churches and Government), Office, Storage/Warehouse, Residential, Other, Vacant Building, Vacant Lot, Parking, and Utilities.

CURRENT AND PROJECTED PARKING DEMAND

Based on the parking demand model used in the *Parking Study*, there will be an increase in both long-term and short-term parking demand over the next several years. For this thesis, the emphasis is on long-term demand. The MPC Study identifies increases in parking demand for 5-year and 15-year horizons. The demand for long-term parking spaces was forecast to be 13,700 in 1994. By the year 2004, the long-term parking demand is forecast to be 17,932. In 1994, the MPC updated the inventory of various land uses and parking supply in the CBD for use in the parking demand model. Their 1994 assessment concluded that the estimated demand for 1994 was 13,494. The 1994 update of the land use information used in the parking demand model and subsequent recalibration of the model with the newer information has led to a parking demand estimate for 1994 that is similar to that

forecast in the 1990 study. If land use and trip generation rates predicted by the parking demand model are correct, then demand for long-term parking will increase by 30.9% from 1994 to 2004 $[(17,932 - 13,700)/13,700]$. This percentage increase will be used as the target for decreases in the percentage vehicle trips as predicted by the model.

The current demand for long-term parking in the CBD and therefore HBW vehicle trips was established. Visual inspections were used to determine the areas to be counted for the sample of commuters utilizing long-term parking spaces in the CBD. On July 13, 1994, counters were given maps with their assigned garages and surface lots in the CBD. Counts were made of the number of vehicles parked in the garages and lots between 8:30 AM and 9:30 AM. Discussions with lot operators and attendants indicated that this time period would capture the commuters arriving in the CBD for purposes of work. Surface lots and the remaining garages were counted in a similar manner on July 14 & 28, 1994. The results of these counts are displayed in Table 4. It should be noted that facility occupancy rates for the CBD are around 50%. This would indicate that, at least during the AM peak, that there is not much of a parking supply problem.

TABLE 4: COUNT TOTALS

	COUNTS	TOTAL SPACES	FACILITY OCCUPANCY RATE
LOTS	2691	4862	0.55
GARAGES	3868	7735	0.50
GRAND TOTAL*	6559	12597	0.52

* An additional 1755 Civic Coliseum Garage space that are not used for commuter parking were not included in this total.

DETERMINATION OF HOME BASED WORK TRIPS

HBW trips were determined for both private vehicles and transit vehicles.

Private Vehicles

The number of HBW private vehicle trips entering the CBD Business Core during the AM peak was estimated from the sample of vehicles utilizing long-term parking facilities in the area shortly after the AM peak. It is assumed that the vehicles parked in the surface lots and garages between 8:30 AM and 9:30 AM are there for long-term, work purposes.

A comparison of the sample drawn for this thesis to the *Parking Study* has been made. The *Parking Study* determined that there were 14,199 off-street (long-term) parking spaces in the CBD. The Study

also found that the average occupancy for most off-street facilities was under 60%. This is consistent with the finding of this thesis.

The counts for each day were corrected using TDOT correction factors obtained from the City of Knoxville Traffic Engineering Office. The corrected daily totals were then summed to arrive at the total parking volume that was used to estimate the daily roadway traffic volume. This is the number that will be used to estimate HBW vehicle trips to the Knoxville CBD. The procedure used to correct the sample is illustrated below. The total number of HBW vehicle trips is rounded to 5909.

Vehicles counted Wednesday, July 13, 1994	3567	
x Correction Factor 0.91		3245.97
Vehicles counted Thursday, July 14, 1994	2903	
x Correction Factor 0.89		2583.67
Vehicles counted Thursday, July 28, 1994	89	
x Correction Factor 0.89		79.21

		5908.85

Transit Trips

Transit HBW trips were determined by using the Corradino Group *Site Selection & Conceptual Design of downtown Intermodal Transportation Center* (Corradino Group 1993). According to the study, 900 downtown workers use K-Trans on a daily basis. This is about 5% of the estimated 17,000 downtown employees. The mode share for transit trips will therefore be 5% for this thesis.

ALTERNATIVE GENERATION

Alternatives showing the impact of changing COST and OVTT on vehicle trips were generated. A cover sheet and worksheet for each alternative is included in Appendix B. The alternatives represent changes in vehicles trips produced by varying the attributes in question within a range established by the threshold values.

Attribute Changes

The potential changes in mode shares and vehicle trips due to changes in the value of certain attributes that are relevant to travel mode preference considered in the worksheets used in this thesis include:

(A) A change in the amount of time commuters must spend getting from their chosen mode to their final destination in the CBD (*Out of Vehicle Travel Time--OVTT*),

(B) A change in the out of pocket cost for getting to the CBD (*Cost--COST*), or

(C) A combination of (A) and (B).

Threshold values for practical feasibility of implementation have been established for each of the attributes under consideration. These

threshold values are intended for application to all modes being evaluated. Thus, variations in time or cost between the modes is accounted for in the average numbers used. The threshold values are summarized as follows:

(A) OVTT--The threshold OVTT figure was established based on the length of time it takes to walk from the farthest parking facility (the Coliseum Parking Garage) to the CBD. An alternative that requires more than +/- 10 minutes is considered infeasible for implementation.

(B) COST--The national figures (DOT, 1994) for operating costs for private vehicles used for work trips and the average parking cost for the Knoxville CBD are the two components that make up the threshold value for COST. Average Daily parking costs for Knoxville have been calculated at \$3.02. This amount will be used as the threshold value for parking COST. National figures indicate that automobile operating costs amount to 54.2 cents per mile (This figure includes gas & oil, maintenance, tires, and fixed costs including insurance, license fees, and depreciation). Multiplying this number by the national average trip length for all vehicles (10.7 miles) yields 579.94 cents or \$5.80 per trip. Adding this to the Knoxville CBD average daily parking cost of \$3.02 yields \$8.82. This amount will be used as the threshold for total operating COST. Average parking cost has been calculated in the spreadsheets included in Appendix A.

Model Application

By applying the Barton-Aschman model discussed in Chapter 3, revised mode shares caused by changes in attributes have been generated. The emphasis of the application of the model was on producing percentage reduction in HBW vehicle trips to the CBD that would counterbalance the 30.9% increase in demand for long term parking in the CBD as predicted in the *Parking Study*.

Attribute changes are accomplished on Worksheet 1. This Worksheet multiplies changes in the attribute under consideration by the coefficient for that attribute for each mode. Addition of the changes in each attribute multiplied by the coefficient for that attribute produce changes in the utility function for that mode (ΔU_i). This number is forwarded to Worksheet 2.

Worksheet 2 exponentiates the changed utility function ($e^{\Delta U_i}$). The number produced by this procedure is then multiplied by the person trips base shares (P_i) to produce revised mode shares (P_i'). Revised mode shares are forwarded to Worksheet 3.

Worksheet 3 takes the revised mode shares produced in Worksheet 2 and multiplies them by the original total person trips to produce revised person trips per mode. Revised person trips are divided by a factor to produce revised vehicle trips. Revised vehicle trips are compared to base vehicle trips in order to establish the percentage change in vehicle trips.

Initial Conditions

Initial conditions for input into the model include:

Corrected HBW vehicle trips	5,909
Total Employment in CBD	17,000
Knox County Average Income	\$26,010

Calculation of HBW Person Trips Base Shares:

HBW Vehicle Trips x Base Vehicle Shares = Private Vehicle Trips

Private Vehicle Trips x Factor = Private Vehicle Person Trips

Private Vehicle Person Trips/0.95 = Total Trips

Total Trips - Private Vehicle Person Trips = Transit Trips

Private Vehicle Person Trips + Transit Trips = Total Person Trips

Total Person Trips for Each Mode / Total Person Trips

= Person Trips Base Shares

The calculations necessary to determine person trips base shares are presented in Table 5.

In Table 6, the results of the alternatives generation are presented. The actual worksheets used can be found in Appendix B./ The highest (most positive) threshold value for each attribute was applied to the SOV mode. The lowest (most negative) threshold value was applied to each of the HOV modes. Alternative 1 tests the OVTT at its highest possible threshold value. Alternative 2 test OVTT at its lowest possible threshold value. Alternatives 3 and 4 test parking COST at its highest and lowest threshold values. Alternatives 5 and 6 test total operating COST at its highest and lowest threshold values. Alternatives 7 and 8 test the combination of OVTT and parking COST at the highest and lowest values of OVTT and parking COST. Alternatives 9 and 10 test the combination of OVTT and total operating COST at their highest and lowest values. The resulting vehicle trip reduction is

TABLE 5: HBW PERSON TRIPS CALCULATION

		BASE VEHICLE SHARES	PRIVATE VEHICLE TRIPS	FACTOR	PRIVATE VEHICLE PERSON TRIPS	TOTAL PERSON TRIPS	PERSON TRIPS BASE SHARES
AUTOS	D A	0.79	4643	1	4643	4643	0.58
	2-CP	0.18	1052	2	2105	2105	0.26
	3-CP	0.03	151	3	452	452	0.06
	4-CP	0.00	36	4	144	144	0.02
	5+ CP	0.00	13	5	64	64	0.01
V-POOL		0.00	14	12	170	170	0.02
TRANSIT						399	0.05
TOTAL		1.00	5909		7578	7977	1.00

TABLE 6: ALTERNATIVES

ALT	SOV OVTT MINUTES	COST CENTS	HOV OVTT MINUTES	COST CENTS	% REDUCTION	COUNTERBALANCE
1	+10				10.7	NO
2			-10		10.7	NO
3		+302			28.4	NO
4				-302	28.4	NO
5		+882			47.3	YES
6				-882	47.3	YES
7	+10	+302			35.2	YES
8			-10	-302	35.2	YES
9	+10	+882			48.0	YES
10			-10	-882	48.0	YES

Note: Counterbalance refers to whether or not the percentage reduction provide enough of a reduction to counterbalance the 30.9% increase in trips predicted in the MPC Parking Study

reported as well as whether or not the attribute change tested provided the counterbalancing reduction of 30.9%.

RESULTS

Of the ten alternatives generated, six produced vehicle trip reduction percentages that were at least 30.9%. A discussion of each Alternative is presented below. Those alternatives that do not produce at least the 30.9% reduction that is being used as a benchmark for percentage overall vehicle trip reductions will be considered as having too little effect to warrant consideration as implementable.

Alternative 1

Alternative 1 involved increasing the OVTT attribute for SOV's by the maximum threshold amount -- 10 minutes. This change caused a 21.7% reduction in SOV vehicle trips. However, only a 10.7% decrease in overall vehicle trips was obtained.

Alternative 2

Alternative 2 involved decreasing the OVTT attribute for each HOV by the minimum threshold amount -- -10 minutes. Like Alternative 1, this alternative caused a decrease of 27.7% in SOV vehicle trips. Also, only a 10.7 % reduction in overall vehicle trips was achieved.

Alternatives 3 & 4

Alternative 3 involved increasing the COST attribute by the maximum threshold amount for parking cost -- \$3.02. Alternative 4 involved increasing the COST attribute by the minimum threshold amount

-- -\$3.02. Both alternatives produced decreases of 57.9% in SOV vehicle trips. However, overall vehicle trips were only reduced by 28.4%

Alternatives 5 & 6

Alternative 5 involved increasing the COST attribute for SOV by the maximum threshold amount for overall cost -- \$8.82. Alternative 6 involved decreasing the COST attribute for each HOV by the minimum threshold amount for overall cost -- -\$8.82. Both alternatives produced 96.6% decreases in SOV vehicle trips. Overall vehicle trips were reduced by 47.3% for both alternatives.

Alternatives 7 & 8

Alternative 7 involved increasing the OVTT for SOV by 10 minutes and the COST for SOV by \$3.02. Alternative 8 involved decreasing the OVTT for each HOV by -10 minutes and COST for each HOV by -\$3.02. Each alternative produced a decline of 71.8% in SOV vehicle trips. The overall vehicle trip reduction was 35.2%

Alternatives 9 & 10

Alternative 9 involved increasing the OVTT for SOV by 10 minutes and the COST for SOV by \$8.76. Alternative 10 involved decreasing the OVTT for each HOV by -10 minutes and decreasing the COST for each HOV by -\$8.76. Both alternatives produced 97.9% decreases in SOV vehicle trips and 48% decreases in overall vehicle trips.

Each of the alternatives considered to warrant further attention -- those producing more than 30.9% overall vehicle trip reductions -- included changing the value of the COST attribute or a combination of attributes that included COST. This finding is in keeping with what

many of the other researchers mentioned in the Literature Review Chapter found: in order to produce any significant reductions in the number of SOV's, the cost of the HBW trip must be manipulated. Additionally, it has been indicated in several of the articles reviewed for this thesis that a combination of parking management and general TDM tactics are necessary to produce an acceptable reduction in HBW trips. The case studies reviewed for this thesis do indicate that reductions of 30.9% are possible. However, the literature indicates inconsistencies in reductions in vehicle trips and it is unclear how long the reductions will last.

Tactics

The TDM tactics and parking management tactics in particular that can be used to reduce SOV HBW trips by changing the COST of the trip or a combination of COST and OVTT will be discussed in this section. Each attribute will be discussed and explained. The emphasis of the discussion will be on ways to encourage SOV's commuters to switch to HOV's. Therefore, the affects of the changes on those commuters already using HOV's will not be discussed. For each tactic, a brief explanation will be provided.

COST

The cost of the HBW trip of a commuter can be changed in a variety of ways. One way involves changing the cost of the whole trip, including gas, oil, maintenance, tires, insurance, license fees, depreciation, and parking. Tolls and congestion pricing (where

vehicles are charged a fee for using a stretch of congested roadway) are two ways to accomplish a change in the cost of the whole trip. Another way of changing the cost involves only a portion of the trip. This form of cost manipulation can be accomplished by increasing or decreasing parking cost. Offering travel allowances to HOV's that cover all or part of the cost of the HBW trip or offering transit or HOV subsidies are also ways to change COST.

OVTT

Changing the amount of time that a commuter must spend getting from her parking space to her final destination can be changed by using preferential parking and/or fringe parking. Requiring SOV's to park farther away from the CBD would cause them to have an increase in OVTT. Allowing HOV's to park in the center of the CBD or at sites designated throughout the CBD which are close to that person's job site will cause a decrease in OVTT.

COMBINATION

Combining the effects of COST and OVTT can be accomplished in many ways. Increasing the cost of parking for SOV's while simultaneously making them park farther away is one possibility. Reducing or eliminating the cost for HOV's while providing close to the job site parking spaces is another.

POLITICAL AND ECONOMIC FEASIBILITY

Issues of Political and Economic concern will be presented and discussed in this section.

Problems

As was mentioned earlier, the City of Knoxville has a history of choosing traditional solutions to transportation problems. Any alternative that would require something other than a build solution will meet with some degree of political opposition. Any large capital outlay for an alternative that has intangible benefits (such as SOV reductions) has the potential to meet with opposition. However, in recent years, the Transportation Improvement Plans (TIP's) for the Knoxville Area have included funding for alternative tactics such as vanpooling and information dissemination. Subsidizing or doubling the entire amount of the HBW trip is an improbable event. The cost of the entire HBW trip is not typically acknowledged by commuters or the politicians representing them.

Politicians charged with implementing any policy changes in the CBD would have to be aware of the variety of stakeholders that would be affected by the change. An increase in the cost of the HBW trip for SOV's would aggravate the SOV's but increase revenue for the entity implementing the cost increase. Subsidizing the cost of the HBW trip for HOV's would benefit those commuters choosing to ride in an HOV. However, the capital to finance the subsidy would have to be obtained from either public (taxes), private (increase in rates), or a combination of public and private sources. Additionally, the tax

payer/voter who does not work in the CBD will not benefit in any tangible way from a policy change in the CBD but might suffer from an increase in taxes. There is also a question of how parking management would effect the low income worker.

In addition to the taxpayer/voter who must commute to the CBD for work purposes, the politician must consider the affects of a policy change on the businesses and business owners in the CBD. A number of businesses pay the cost of parking for their employees in the CBD. An increase in the amount they must pay to provide their employees with parking could be damaging for the revenues of that business and therefore the taxes that business will pay. Also, businesses may find it harder to recruit employees to an area with high parking costs for SOV's. This situation may make the CBD an unappealing setting for doing business--making current tenants move out and discouraging new tenants from moving in. The city's tax-base would be eroded by businesses that choose to operate in another city.

Parking lot owners and operators would have mixed impacts as a result of a policy change. Although fewer HBW trips would cause a decrease in revenue from long-term parkers for lot operators, the decrease would free space for short-term parkers which would mean an increase in the turnover rate for the lots or garages. Since short-term rates are generally higher than long term rates, the operators would benefit (assuming that the CBD continues to grow).

Thus far, the issues associated with changing the cost of the HBW trip have been emphasized. An increase in OVTT is also problematic. Weather conditions in Knoxville are not usually severe,

but there are no amenities that would protect those SOV commuters having to walk from a distant parking area. Increasing the OVTT would also require the SOV's and lot operators to be monitored for compliance with parking regulations concerning location.

Benefits

The most obvious benefit of changing the policies affecting parking in the CBD involves cost. Increasing cost for SOV's would generate income for the entity that levies the increase. This would likely be the local government. Revenues could be used for additional amenities in the CBD that would benefit pedestrians, HOV users, bikers, etc.

Other benefits of a change in policy may not be as obvious. Air quality improvements would be evidenced if fewer vehicles were on the road. Congestion in the CBD would also decrease.

An issue that can not be ignored is the fact that Knoxville would be in compliance with the major legislation affecting commuters--the CAAA and ISTEA mentioned earlier in this thesis. Penalties for non-compliance would be avoided and funding of alternative tactics could be secured.

Parking Management Alternatives versus the Build Alternative

The propensity to build the way out of transportation problems has been indicated throughout this thesis. Recently, a Municipal Garage was constructed in the CBD. Although this garage was located in a "fringe" area, it added spaces to an already sufficient supply of parking. The garage was constructed in answer to mounting political

pressure on the part of commuters and business to increase the convenience of parking. No consideration was given to alternative solutions. The current attitude of government, businesses, and commuters in the CBD is short range in nature. Proactive policies to alleviate potential, future problems are not being considered at this time.

CHAPTER 5 CONCLUSION

This chapter will conclude the research conducted for this thesis. A summary of the findings will be presented that will highlight the important aspects of the impacts of parking management in the Knoxville CBD. A review of the assumptions that were made concerned the coefficients used in the logit model, the existing conditions in the Knoxville CBD, the threshold values, and the practical aspects of implementation. Following the summary and review of assumptions will be a presentation of future considerations.

SUMMARY OF FINDINGS AND REVIEW OF ASSUMPTIONS

After using the logit model to produce alternatives, it was shown that parking management could produce reductions in the sample of HBW vehicle trips that would at least counterbalance the expected increases in vehicle trips as predicted in the *Parking Study*. It was found that changing the attribute COST would produce the most significant amount of change in the propensity of an SOV to change to an HOV. It was also noted that a combination of attribute changes could produce a viable alternative. The literature reviewed for this thesis indicates that reductions in the SOV rate that are near the 30.9% required for this thesis can be accomplished when COST is manipulated. It was also noted

in the literature that making policy changes that affect the cost of HBW trips is often difficult.

The intention of this thesis has been to ascertain what parking management options are available for implementation in medium sized cities such as Knoxville and which ones will produce the necessary reductions in the SOV rate for the sample. The Knoxville Case study illustrates a procedure that can be used by other mid-sized communities that expect growth and wish to test the possibility of including parking management in transportation planning in order to pro-actively deal with an increase in vehicle trips. The same general procedures could be used with modified assumptions.

The question of which alternatives will produce the off-setting reductions in the SOV rate was simple enough to answer using the logit model. However, the model produces answers using assumptions and hypothetical situations. In order to use the model, coefficients that were compiled from several other cities' experience with valuing the attributes in question were used to show expected changes in the probability of an SOV commuter changing modes of travel in the Knoxville CBD. The reductions experienced in those cities may not be experienced in the Knoxville CBD considering that the City-County government provides preferential treatment and subsidies to its employees that are not fully used and that there is an oversupply of parking for long term purposes at this time. Additionally, the input values for the model were all taken from samples of the Knoxville CBD commuting population. The travel time and total trip cost values used to establish thresholds were taken from national statistics. The

increase in HBW trips was taken from the results of another model that assumed an expansion in employment in the CBD. Each of these assumptions makes the conclusions reached less certain.

Which parking management tactics are available for use in the Knoxville CBD is also a simple question to answer, if assumptions are made concerning implementation. Assumptions concerning how much of an increase in a given attribute would be tolerated by the various stakeholders were formed from reviewing historical information taken from the Knoxville News Sentinel and observation. It has also been assumed that the stakeholders and decision makers in the Knoxville CBD would consider the anticipated increase in HBW trips a transportation problem.

A question that is beyond the scope of this thesis would be, will parking management ever be implemented in the Knoxville CBD or in other mid-sized communities in order to proactively deal with anticipated transportation problems. After reviewing the literature and generating alternatives with the model, it has been determined that parking management has the potential to produce the desired changes. With the impetus provided by the ISTEA and CAAA, there may be more emphasis placed on non-traditional solutions. This paradigm shift can not, however, be predicted by a model. Alternatives such as parking management can be presented for discussion and possible inclusion in dialogs concerning future transportation solutions.

FUTURE CONDITIONS

The assumptions and findings of this thesis were based on the presumption that the "state of the art" in transportation solutions would be the same in ten years as it is now. However, several situations are developing that may determine the future transportation solutions in areas such as the Knoxville CBD over the next ten years.

- Telecommunication and the concept of working at home have the potential to significantly impact the travel patterns of a city such as Knoxville. If telecommuting becomes a viable option for businesses in the Knoxville CBD, then increases in the SOV rate may not occur.
- The use of flextime and modified work days is becoming more popular. This could change the dynamics of the CBD.
- Intelligent Transportation Systems are gaining momentum as solutions to avoiding congested roadways, thereby reducing the potential for increased pollutants being emitted by idling vehicles. Other applications of this technology could also benefit the CBD commuters.

- Business downsizing and the use of less labor intensive manufacturing processes may also negate the anticipated increase in HBW trips to the CBD.

These and other non-traditional transportation solutions, such as parking management, may be the "state of the art" in transportation planning in the future.

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APPENDICIES

APPENDIX A

COUNTS FOR THE KNOXVILLE CBD

COUNTS FOR JULY 13, 1994

GARAGES

NAME	OP/OWN	SPACES	COUNT	RATES		RATE X RATE X SPACES PAID SPACES	
				DAILY	MONTHLY		
PLAZA	JMB	400	185	\$8.00	\$85.00	\$3,200.00	\$3,200.00
RIVERVIEW CENT		1052	239	\$7.00	\$80.00	\$7,364.00	\$7,364.00
KESSEL	A-R	1000	417	\$3.00	\$55.00	\$3,000.00	\$3,000.00
NATIONS	A-R	471	313	\$3.50	\$65.00	\$1,648.50	\$1,648.50
CITY/CO	A-R	834	577	\$5.00	\$30.00	\$4,170.00	\$4,170.00
HILTON	A-R	400	212	\$4.00	\$65.00	\$1,600.00	\$1,600.00
HOLIDAY I REPUB		465	163	\$2.50	\$32.48	\$1,162.50	\$1,162.50
UT	UT	330	163		\$13.80	\$379.50	\$379.50
SUMMER PL CENT		695	456		\$46.55	\$1,078.41	\$1,078.41
STATE ST	A-R	800	533	\$2.50	\$46.00	\$2,000.00	\$2,000.00
TOTAL GAR		6447	3258			\$25,602.91	

LOTS

	OP/OWN	SPACES	COUNT	RATES			
				DAILY	MONTHLY		
	A-R	173	100	\$4.00		\$692.00	\$692.00
	TVA	25	20	\$0.00		\$0.00	
	KINKOS	21	12	\$0.00		\$0.00	
	CENT	42	40	\$2.00	\$35.18	\$84.00	\$84.00
	TN	141	137	\$0.00	\$0.00	\$0.00	
TOTAL LOTS		402	309			\$776.00	\$776.00
						\$1,552.00	
TOTAL FOR JULY 13, 1994		6849	3567			\$27,154.91	

COUNTS FOR JULY 14, 1994

	OP/OWN	SPACES	COUNT	RATES			
				DAILY	MONTHLY		
NORTHERN SECTOR							
	A-R	75	59	\$3.25		\$243.75	\$243.75
	P*	10	9	\$0.00		\$0.00	
	A-R	84	84	\$2.25		\$189.00	\$189.00
	P	70	2	\$0.00		\$0.00	
	TVA VAN*	30	17		\$34.52	\$34.52	\$34.52
	CARPN*	30	21		\$34.52	\$34.52	\$34.52
	EAGLES*	20	11		\$34.52	\$23.01	\$23.01
	A-R	74	54		\$34.52	\$85.15	\$85.15
	A-R	10	12	\$3.25		\$32.50	\$32.50
	P*	10	6	\$0.00		\$0.00	
	P*	10	1	\$0.00		\$0.00	
	TN ARM*	40	32	\$0.00		\$0.00	
	CW COR*	100	7	\$0.00		\$0.00	
	JH DAN*	150	58	\$0.00		\$0.00	
	A-R	123	4	\$1.00		\$123.00	\$123.00
	A-R	99	59	\$0.75		\$74.25	\$74.25
	A-R	99	54	\$1.50		\$148.50	\$148.50
	A-R*	150	67	\$0.50		\$75.00	\$75.0094

JFG*	20	13	\$0.00		\$0.00	
UNDG*	7	4	\$0.00		\$0.00	
OUTRAD*	30	25	\$0.00		\$0.00	
FORT*	75	36		\$25.00	\$62.50	\$62.50
L&N*	100	60	\$0.00		\$0.00	
SUNSPH	30	27	\$0.00		\$0.00	
UT-11TH	125	53		\$13.80	\$57.50	\$57.50
CAF MET	35	35	\$1.00		\$35.00	\$35.00
TOTAL	1606	810			\$1,218.20	
	0.504359					

EASTERN SECTION

P*	15	3	\$0.00		\$0.00	
BROWN	26	20	\$0.00		\$0.00	
LAW	30	18	\$0.00		\$0.00	
P	21	12	\$0.00		\$0.00	
KUB*	25	15	\$0.00		\$0.00	
P	40	26	\$0.00		\$0.00	
P	46	33	\$0.00		\$0.00	
P	10	6	\$0.00		\$0.00	
P	22	11	\$0.00		\$0.00	
CLEMN	9	6	\$0.00		\$0.00	
MPWR	26	13	\$0.00		\$0.00	
P	9	9	\$0.00		\$0.00	
P	8	7	\$0.00		\$0.00	
CENT	147	93	\$3.00		\$441.00	\$441.00
SENTL*	25	16	\$0.00		\$0.00	
A-R	35	11	\$7.00		\$245.00	\$245.00
P*	12	2	\$0.00		\$0.00	
A-R	36	18	\$2.50		\$90.00	\$90.00
A-R	18	16	\$2.25		\$40.50	\$40.50
CENT	38	29		\$55.00	\$154.00	\$154.00
A-R	40	18	\$2.25		\$90.00	\$90.00
A-R	21	19	\$2.25		\$47.25	\$47.25
A-R	38	39	\$1.75		\$66.50	\$66.50
A-R	47	37	\$1.75		\$82.25	\$82.25
SENTL*	50	7	\$0.00		\$0.00	
P*	23	8	\$0.00		\$0.00	
P*	50	13	\$0.00		\$0.00	
EZP	47	53	\$1.75		\$82.25	\$82.25
REPUB	63	32	\$2.25		\$141.75	\$141.75
P*	30	12	\$0.00		\$0.00	
METERS	103	103	\$1.00		\$103.00	\$103.00
TOTAL	1110	705			\$1,583.50	
	0.635135					

CENTRAL SECTOR

METH	116	72		\$20.00	\$77.33	\$77.33
A-R	198	90	\$1.75		\$346.50	\$346.50
A-R	42	46	\$3.75		\$157.50	\$157.50
CENT	68	39	\$3.00		\$204.00	\$204.00
P	31	23	\$0.00		\$0.00	
CENT	27	22		\$45.00	\$40.50	\$40.50
CENT	62	19		\$45.00	\$93.00	\$93.00
CENT	82	52	\$2.50		\$205.00	\$205.00

A-R	200	71	\$2.75		\$550.00	\$550.00
P	25	22	\$0.00		\$0.00	
CENT	56	35	\$5.00		\$280.00	\$280.00
P	21	9	\$0.00		\$0.00	
1ST AM	36	23	\$0.00		\$0.00	
CENT	99	95	\$5.25		\$519.75	\$519.75
A-R	22	21	\$4.50		\$99.00	\$99.00
A-R	55	27	\$4.50		\$247.50	\$247.50
FED	18	6	\$0.00		\$0.00	
P.O.	38	18	\$0.00		\$0.00	
A-R	35	24	\$2.75		\$96.25	\$96.25
P	44	33	\$0.00		\$0.00	
P	5	2	\$0.00		\$0.00	
P	7	6	\$0.00		\$0.00	
CENT	71	36	\$3.00		\$213.00	\$213.00
A-R	51	34	\$2.75		\$140.25	\$140.25
A-R	75	15		\$27.00	\$67.50	\$67.50
A-R	75	27		\$24.00	\$60.00	\$60.00
TOTAL	1559	867			\$3,397.08	
	0.556126					

GARAGES

RAD	212	50	\$5.00		\$1,060.00	\$1,060.00
COL	700	209	\$3.00		\$2,100.00	\$2,100.00
EZ P	96	50	\$2.25	\$42.00	\$134.40	\$134.40
PRMD	280	212	\$2.25	\$40.00	\$630.00	\$630.00
	1288	521			\$3,924.40	

TOTAL FOR JULY 14, 1994

LOTS	4275	2382			\$6,198.79	
GARAGES	1288	521			\$3,924.40	
	5563	2903			\$10,123.19	

COUNTS FOR JULY 28, 1994

MEDICAL ARTS GARAGE	185	89	\$4.00	\$65.25	\$740.00	\$740.00
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OVERALL TOTALS

		SPACES	COUNT	%OCC	
LOTS &		402	309	0.77	
GAR 7/13		6447	3258	0.51	
LOTS &		4275	2382	0.56	
GAR 7/14		1288	521		
GAR 7/28		185	89	0.48	
TOTAL	LOTS	4677	2691	0.58	
	GAR	7920	3868	0.49	
TOTAL		12597	6559	0.52	\$38,018.09

AVERAGE DAILY PARKING \$3.02

AVERAGE PAID PARKING \$3.41

PERCENTAGE FREE PARKING 11%

NOTES:

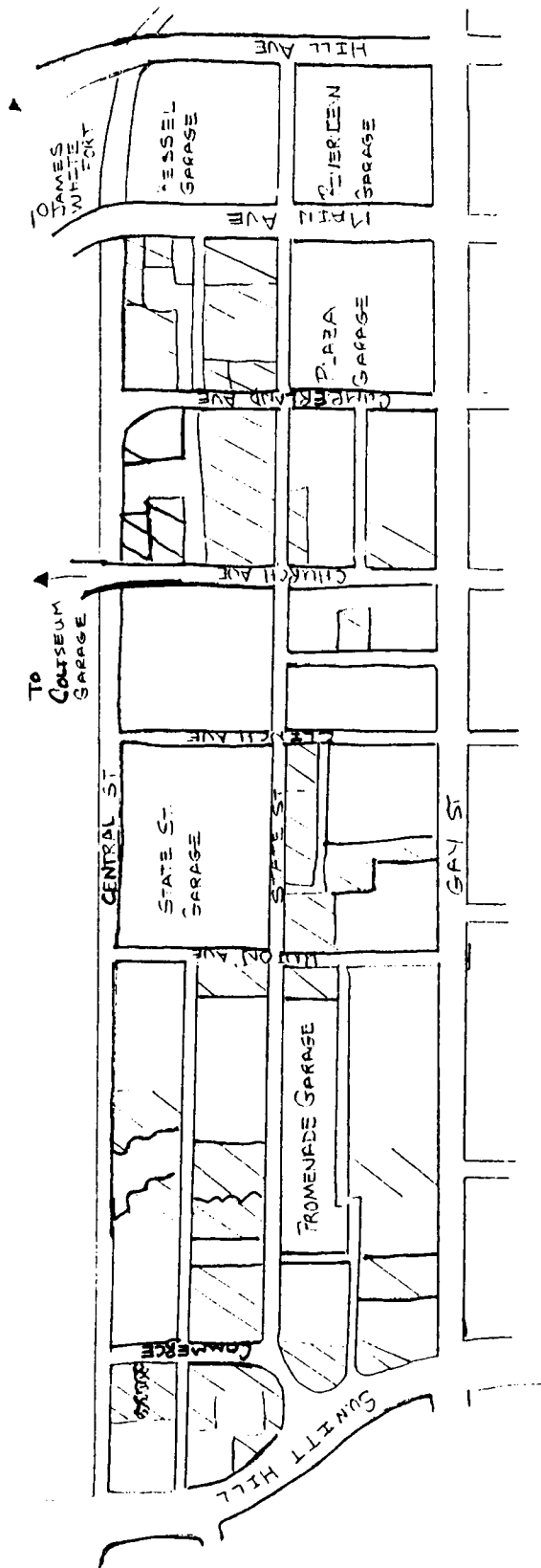
* INDICATES ESTIMATED SPACES

LOT OPERATOR NAMES HAVE BEEN ABBREVIATED TO SAVE SPACE

P = PRIVATE

A-R = ALL RIGHT

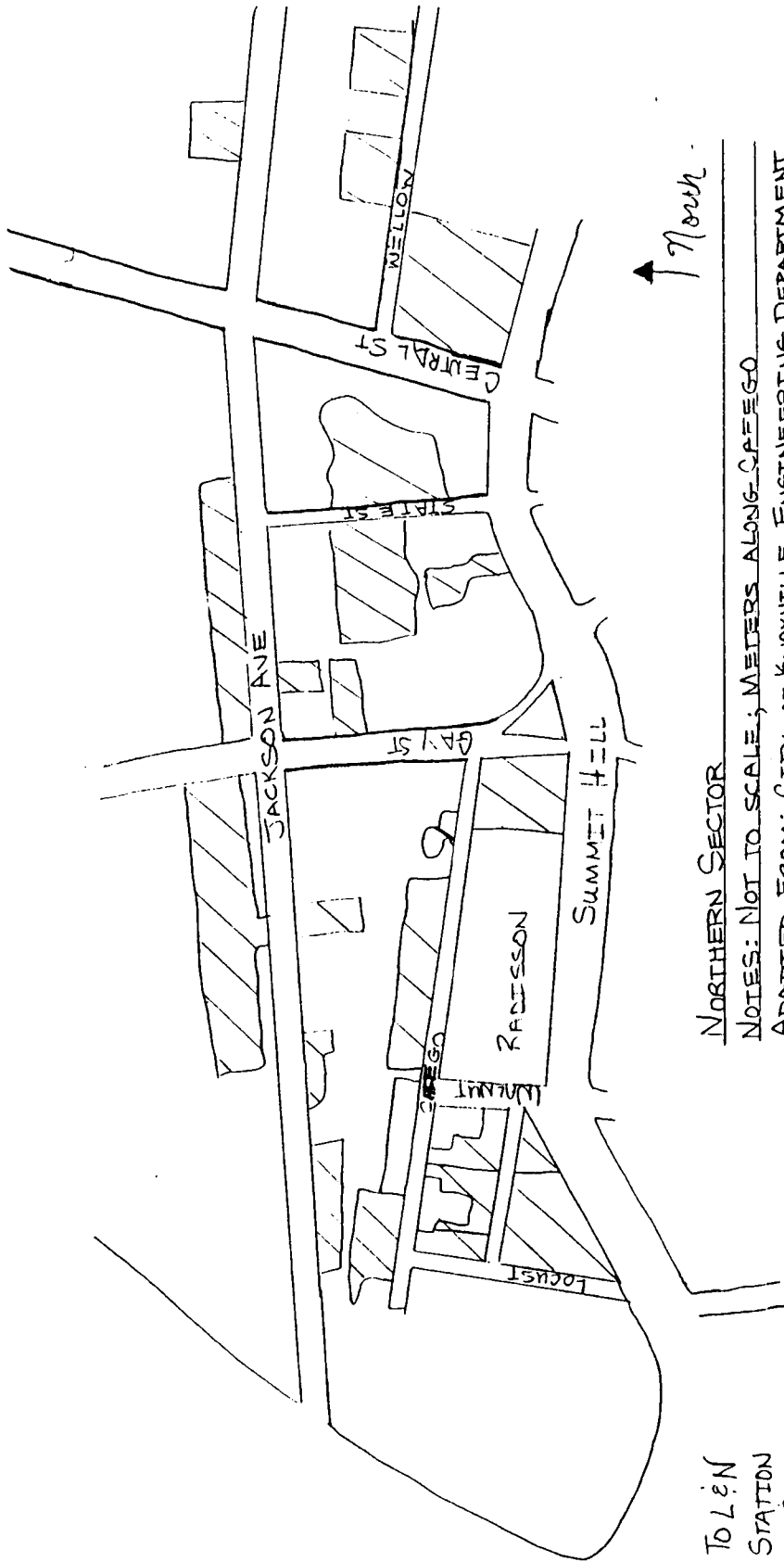
CENT = CENTRAL



EASTERN SECTOR

NOTES: NOT TO SCALE; METERS ALONG CENTRAL ST, CUMBERLAND AVE., & STATE ST.
 -SOURCE: ADAPTED FROM CITY OF KNOXVILLE ENGINEERING DEPARTMENT PLANIMETRIC
 MAPS, 1994.

← North



NORTHERN SECTOR

NOTES: NOT TO SCALE; METERS ALONG CAFEGO

ADAPTED FROM: CITY OF KNOXVILLE ENGINEERING DEPARTMENT

PLANIMETRIC MAP, 1994.

APPENDIX B

ALTERNATIVE 1

ATTRIBUTE CHANGED: OVTT

MODE CHANGED: SOV

AMOUNT OF CHANGE: +10 MINUTES (MAXIMUM OVTT THRESHOLD)

RESULTING REDUCTION: 10.7%

WORKSHEET 1							
26010							
AVERAGE INCOME	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
		COEF		COEF		COEF	Ui
AUTO							
D A	0.000	-0.025	10.000	-0.050	0.000	-0.005	-0.500
2-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
3-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
4-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
5+ CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
V POOL	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
BUS	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	-0.500	0.607	0.352	0.456	0.58
2-CP	0.000	1.000	0.260	0.337	0.26
3-CP	0.000	1.000	0.060	0.078	0.06
4-CP	0.000	1.000	0.020	0.026	0.02
5+ CP	0.000	1.000	0.010	0.013	0.01
V-POOL	0.000	1.000	0.020	0.026	0.02
BUS	0.000	1.000	0.050	0.065	0.05
TOTAL			0.772	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.456	3636 1.000	3636	4643	-0.217
2-CP	0.337	2687 2.000	1344	1052	0.277
3-CP	0.078	620 3.000	207	151	0.372
4-CP	0.026	207 4.000	52	36	0.433
5+ CP	0.013	103 5.000	21	13	0.605
V-POOL	0.026	207 12.000	17	14	0.216
BUS	0.065	517			
TOTAL	1.000	7977	5276	5909	-0.107

ALTERNATIVE 2

ATTRIBUTE CHANGED: OVTT

MODE CHANGED: EACH HOV BY SAME AMOUNT

AMOUNT OF CHANGE: -10 MINUTES (MINIMUM OVTT THRESHOLD)

RESULTING REDUCTION: 10.7%

WORKSHEET 1							
26010							
AVERAGE INCOME	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
		COEF		COEF		COEF	Ui
AUTO							
D A	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
2-CP	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500
3-CP	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500
4-CP	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500
5+ CP	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500
V POOL	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500
BUS	0.000	-0.025	-10.000	-0.050	0.000	-0.005	0.500

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	0.000	1.000	0.58	0.46	0.58
2-CP	0.500	1.649	0.43	0.34	0.26
3-CP	0.500	1.649	0.10	0.08	0.06
4-CP	0.500	1.649	0.03	0.03	0.02
5+ CP	0.500	1.649	0.02	0.01	0.01
V-POOL	0.500	1.649	0.03	0.03	0.02
BUS	0.500	1.649	0.08	0.06	0.05
TOTAL			1.272	1.000	1.00

WORKSHEET 3

	REVISED SHARES P i '	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.46	3636 1.000	3636	4643	-0.217
2-CP	0.34	2687 2.000	1344	1052	0.277
3-CP	0.08	620 3.000	207	151	0.372
4-CP	0.03	207 4.000	52	36	0.433
5+ CP	0.01	103 5.000	21	13	0.601
V-POOL	0.03	207 12.000	17	14	0.216
BUS	0.06	517			
TOTAL	1.000	7977	5276	5909	-0.107

ALTERNATIVE 3

ATTRIBUTE CHANGED: COST

MODE CHANGED: SOV

AMOUNT OF CHANGE: +\$3.02 (MAXIMUM PARKING COST THRESHOLD)

RESULTING REDUCTION: 28.4%

WORKSHEET 1							
AVERAGE INCOME		26010					
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
AUTO		COEF		COEF		COEF	Ui
D A	0.000	-0.025	0.000	-0.050	302.000	-0.005	-1.449
2-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
3-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
4-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
5+ CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
V POOL	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
BUS	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	-1.449	0.235	0.136	0.245	0.58
2-CP	0.000	1.000	0.260	0.467	0.26
3-CP	0.000	1.000	0.060	0.108	0.06
4-CP	0.000	1.000	0.020	0.036	0.02
5+ CP	0.000	1.000	0.010	0.018	0.01
V-POOL	0.000	1.000	0.020	0.036	0.02
BUS	0.000	1.000	0.050	0.090	0.05
TOTAL			0.556	1.000	1.00

WORKSHEET 3

	REVISED SHARES P1'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.245	1953 1.000	1953	4643	-0.579
2-CP	0.467	3729 2.000	1865	1052	0.772
3-CP	0.108	861 3.000	287	151	0.903
4-CP	0.036	287 4.000	72	36	0.988
5+ CP	0.018	143 5.000	29	13	1.227
V-POOL	0.036	287 12.000	24	14	0.687
BUS	0.090	717			
TOTAL	1.000	7977	4229	5909	-0.284

ALTERNATIVE 4

ATTRIBUTE CHANGED: COST

MODE CHANGED: EACH HOV BY SAME AMOUNT

AMOUNT OF CHANGE: -\$3.02 (MINIMUM PARKING COST THRESHOLD)

RESULTING REDUCTION: 28.4%

WORKSHEET 1							
AVERAGE INCOME		26010					
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
AUTO		COEF		COEF		COEF	Ui
D A	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
2-CP	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449
3-CP	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449
4-CP	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449
5+ CP	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449
V POOL	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449
BUS	0.000	-0.025	0.000	-0.050	-302.000	-0.005	1.449

WORKSHEET 2					
	CUi	eCui	Pi*eCui	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	0.000	1.000	0.580	0.245	0.58
2-CP	1.449	4.259	1.107	0.467	0.26
3-CP	1.449	4.259	0.256	0.108	0.06
4-CP	1.449	4.259	0.085	0.036	0.02
5+ CP	1.449	4.259	0.043	0.018	0.01
V-POOL	1.449	4.259	0.085	0.036	0.02
BUS	1.449	4.259	0.213	0.090	0.05
TOTAL			2.369	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.245	1953 1.000	1953	4643	-0.579
2-CP	0.467	3729 2.000	1865	1052	0.772
3-CP	0.108	861 3.000	287	151	0.903
4-CP	0.036	287 4.000	72	36	0.988
5+ CP	0.018	143 5.000	29	13	1.227
V-POOL	0.036	287 12.000	24	14	0.687
BUS	0.090	717			
TOTAL	1.000	7977	4229	5909	-0.284

ALTERNATIVE 5

ATTRIBUTE CHANGED: COST

MODE CHANGED: SOV

AMOUNT OF CHANGE: +\$8.82 (MAXIMUM TOTAL COST THRESHOLD)

RESULTING REDUCTION: 47.3%

WORKSHEET 1							
AVERAGE INCOME		26010					
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
AUTO		COEF		COEF		COEF	Ui
D A	0.000	-0.025	0.000	-0.050	882.000	-0.005	-4.232
2-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
3-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
4-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
5+ CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
V POOL	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
BUS	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	-4.232	0.015	0.008	0.020	0.58
2-CP	0.000	1.000	0.260	0.607	0.26
3-CP	0.000	1.000	0.060	0.140	0.06
4-CP	0.000	1.000	0.020	0.047	0.02
5+ CP	0.000	1.000	0.010	0.023	0.01
V-POOL	0.000	1.000	0.020	0.047	0.02
BUS	0.000	1.000	0.050	0.117	0.05
TOTAL			0.428	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.020	157 1.000	157	4643	-0.966
2-CP	0.607	4841 2.000	2421	1052	1.300
3-CP	0.140	1117 3.000	372	151	1.471
4-CP	0.047	372 4.000	93	36	1.581
5+ CP	0.023	186 5.000	37	13	1.891
V-POOL	0.047	372 12.000	31	14	1.190
BUS	0.117	931			
TOTAL	1.000	7977	3111	5909	-0.473

ALTERNATIVE 6

ATTRIBUTE CHANGED: COST

MODE CHANGED: EACH HOV BY SAME AMOUNT

AMOUNT OF CHANGE: -\$8.82 (MINIMUM TOTAL COST THRESHOLD)

RESULTING REDUCTION: 47.3%

WORKSHEET 1							
AVERAGE INCOME		26010					
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
AUTO		COEF		COEF		COEF	Ui
D A	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
2-CP	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232
3-CP	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232
4-CP	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232
5+ CP	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232
V POOL	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232
BUS	0.000	-0.025	0.000	-0.050	-882.000	-0.005	4.232

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	0.000	1.000	0.580	0.020	0.58
2-CP	4.232	68.853	17.902	0.607	0.26
3-CP	4.232	68.853	4.131	0.140	0.06
4-CP	4.232	68.853	1.377	0.047	0.02
5+ CP	4.232	68.853	0.689	0.023	0.01
V-POOL	4.232	68.853	1.377	0.047	0.02
BUS	4.232	68.853	3.443	0.117	0.05
TOTAL			29.498	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.020	157 1.000	157	4643	-0.966
2-CP	0.607	4841 2.000	2421	1052	1.300
3-CP	0.140	1117 3.000	372	151	1.471
4-CP	0.047	372 4.000	93	36	1.581
5+ CP	0.023	186 5.000	37	13	1.891
V-POOL	0.047	372 12.000	31	14	1.190
BUS	0.117	931			
TOTAL	1.000	7977	3111	5909	-0.473

ALTERNATIVE 7

ATTRIBUTE CHANGED: COMBINATION

MODE CHANGED: SOV

AMOUNT OF CHANGE: OVTT +10 MINUTES

COST +\$3.02

RESULTING REDUCTION: 35.2%

WORKSHEET 1							
AVERAGE INCOME	26010						
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
	COEF	COEF	COEF	COEF		COEF	Ui
AUTO							
D A	0.000	-0.025	10.000	-0.050	302.000	-0.005	-1.949
2-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
3-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
4-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
5+ CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
V POOL	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
BUS	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	-1.949	0.142	0.083	0.164	0.58
2-CP	0.000	1.000	0.260	0.517	0.26
3-CP	0.000	1.000	0.060	0.119	0.06
4-CP	0.000	1.000	0.020	0.040	0.02
5+ CP	0.000	1.000	0.010	0.020	0.01
V-POOL	0.000	1.000	0.020	0.040	0.02
BUS	0.000	1.000	0.050	0.099	0.05
TOTAL			0.503	1.000	1.00

WORKSHEET 3

	REVISED SHARES P1'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.164	1311 1.000	1311	4643	-0.718
2-CP	0.517	4127 2.000	2063	1052	0.960
3-CP	0.119	952 3.000	317	151	1.106
4-CP	0.040	317 4.000	79	36	1.200
5+ CP	0.020	159 5.000	32	13	1.464
V-POOL	0.040	317 12.000	26	14	0.867
BUS	0.099	794			
TOTAL	1.000	7977	3829	5909	-0.352

ALTERNATIVE 8

ATTRIBUTE CHANGED: COMBINATION

MODE CHANGED: EACH HOV BY SAME AMOUNT

AMOUNT OF CHANGE: OVTT -10 MINUTES

COST -\$3.02

RESULTING REDUCTION: 35.2%

WORKSHEET 1							
26010							
AVERAGE INCOME	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
		COEF		COEF		COEF	Ui
AUTO							
D A	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
2-CP	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949
3-CP	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949
4-CP	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949
5+ CP	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949
V POOL	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949
BUS	0.000	-0.025	-10.000	-0.050	-302.000	-0.005	1.949

WORKSHEET 2					
	CUi	eCUi	Pi*eCUi	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	0.000	1.000	0.580	0.164	0.58
2-CP	1.949	7.022	1.826	0.517	0.26
3-CP	1.949	7.022	0.421	0.119	0.06
4-CP	1.949	7.022	0.140	0.040	0.02
5+ CP	1.949	7.022	0.070	0.020	0.01
V-POOL	1.949	7.022	0.140	0.040	0.02
BUS	1.949	7.022	0.351	0.099	0.05
TOTAL			3.529	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.164	1311 1.000	1311	4643	-0.718
2-CP	0.517	4127 2.000	2063	1052	0.960
3-CP	0.119	952 3.000	317	151	1.106
4-CP	0.040	317 4.000	79	36	1.200
5+ CP	0.020	159 5.000	32	13	1.464
V-POOL	0.040	317 12.000	26	14	0.867
BUS	0.099	794			
TOTAL	1.000	7977	3829	5909	-0.352

ALTERNATIVE 9

ATTRIBUTE CHANGED: COMBINATION

MODE CHANGED: SOV

AMOUNT OF CHANGE: OVTT +10 MINUTES

COST +\$8.82

RESULTING REDUCTION: 48.0%

WORKSHEET 1							
26010							
AVERAGE INCOME	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
		COEF		COEF		COEF	U _i
AUTO							
D A	0.000	-0.025	10.000	-0.050	882.000	-0.005	-4.732
2-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
3-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
4-CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
5+ CP	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
V POOL	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
BUS	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000

WORKSHEET 2					
	CUI	eCUI	Pi*eCUI	REVISED SHARES	BASE SHARES P _i
AUTO					
D A	-4.732	0.009	0.005	0.012	0.58
2-CP	0.000	1.000	0.260	0.612	0.26
3-CP	0.000	1.000	0.060	0.141	0.06
4-CP	0.000	1.000	0.020	0.047	0.02
5+ CP	0.000	1.000	0.010	0.024	0.01
V-POOL	0.000	1.000	0.020	0.047	0.02
BUS	0.000	1.000	0.050	0.118	0.05
TOTAL			0.425	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.012	96 1.000	96	4643	-0.979
2-CP	0.612	4879 2.000	2439	1052	1.318
3-CP	0.141	1126 3.000	375	151	1.490
4-CP	0.047	375 4.000	94	36	1.601
5+ CP	0.024	188 5.000	38	13	1.913
V-POOL	0.047	375 12.000	31	14	1.207
BUS	0.118	938			
TOTAL	1.000	7977	3073	5909	-0.480

ALTERNATIVE 10

ATTRIBUTE CHANGED: COMBINATION

MODE CHANGED: EACH HOV BY SAME AMOUNT

AMOUNT OF CHANGE: OVTT -10 MINUTES

COST -\$8.82

RESULTING REDUCTION: 48.0%

WORKSHEET 1							
AVERAGE INCOME		26010					
	CIVTT	IVTT	COVTT	OVTT	CCOST	COST	CHANGE
AUTO		COEF		COEF		COEF	Ui
D A	0.000	-0.025	0.000	-0.050	0.000	-0.005	0.000
2-CP	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732
3-CP	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732
4-CP	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732
5+ CP	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732
V POOL	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732
BUS	0.000	-0.025	-10.000	-0.050	-882.000	-0.005	4.732

WORKSHEET 2					
	CUi	eCui	Pi*eCui	REVISED SHARES	BASE SHARES Pi
AUTO					
D A	0.000	1.000	0.580	0.012	0.58
2-CP	4.732	113.519	29.515	0.612	0.26
3-CP	4.732	113.519	6.811	0.141	0.06
4-CP	4.732	113.519	2.270	0.047	0.02
5+ CP	4.732	113.519	1.135	0.024	0.01
V-POOL	4.732	113.519	2.270	0.047	0.02
BUS	4.732	113.519	5.676	0.118	0.05
TOTAL			48.258	1.000	1.00

WORKSHEET 3

	REVISED SHARES Pi'	REVISED PERSON TRIPS FACTOR	REVISED VEHICLE TRIPS	BASE VEHICLE TRIPS	% CHANGE
AUTO					
D A	0.012	96 1.000	96	4643	-0.979
2-CP	0.612	4879 2.000	2439	1052	1.318
3-CP	0.141	1126 3.000	375	151	1.490
4-CP	0.047	375 4.000	94	36	1.601
5+ CP	0.024	188 5.000	38	13	1.913
V-POOL	0.047	375 12.000	31	14	1.207
BUS	0.118	938			
TOTAL	1.000	7977	3073	5909	-0.480

VITA

Kimberly K. Henry was born in Maryville, Tennessee on November 25, 1965. She attended elementary schools in the Blount County School District and graduated from Heritage High School in June of 1984. In August of that year, she entered the University of Tennessee at Knoxville and received a BS in Statistics in June of 1988. In 1992, Ms. Henry reentered the University of Tennessee at Knoxville in pursuit of a Master of Science in Planning. Ms. Henry received her MSP in December of 1994 after much hard work.