Analysis of Employer-Based High Occupancy Vehicle (HOV) Policies in the Interstate 5 Corridor Between Seattle and Everett

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16. ABSTRACT

Transportation demand management (TDM) has received increasing attention in recent years as an important component in approaches to improving the transportation system. Another approach to transportation system improvement is the use of high occupancy vehicle (HOV) facilities. Mode choice forecasts provide the basis for planning, project evaluation, and obtaining public support for TDM measures and improvements to the HOV system.

Despite the importance of accurate mode forecasts, current mode choice methodology is insufficiently responsive to factors that influence shifts to ridesharing modes, particularly TDM policy factors that are important in encouraging commuters to shift from single occupant vehicles (SOVs). The objective of this study is to identify these mode choice factors and use them to improve the ability to analyze HOV policies for the north I-5 corridor.

Two major sets of data were analyzed in this study, both collected by Metro in cooperation with Community Transit. In one study, some 9,324 employees of 23 cooperating businesses were surveyed in north King and urban Snohomish counties. In another, a 1989 telephone survey questioned a random sample of 3,586 residents in the study area.

Several analytical approaches were used in this study, including multinomial logit modeling, factor analysis and cluster analysis. Many of the findings from this study are important to understanding the nature of mode choice. Some of the results are important for policy recommendations. Some of the results indicate a different emphasis for employer-based TDM measures in a largely suburban area than in a major CBD such as Seattle or Bellevue.

Study findings indicate the importance of (1) completing the HOV lane system, (2) providing workplace incentives for ridesharing, (3) taking the existence of two-worker households into account, (4) providing alternative ways for employees to run errands, (5) encouraging mixed use through flexible zoning laws, (6) providing non-motorized vehicle alternatives for short commutes, and (7) targeting mode shift incentives and promotions to those most likely to change modes.

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ANALYSIS OF EMPLOYER-BASED HIGH OCCUPANCY VEHICLE (HOV) POLICIES IN THE INTERSTATE 5 CORRIDOR BETWEEN SEATTLE AND EVERETT

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EXECUTIVE SUMMARY

Transportation demand management (TDM) has received increasing attention in recent years as an important component in approaches to improve the transportation system. Recent legislation has encouraged and, in some cases, required employers and jurisdictions to implement TDM programs. The attention to TDM measures is not expected to diminish in the coming years. Employers and local jurisdictions are very interested in understanding and forecasting the impacts of various TDM options.

Another approach to transportation system improvement is the use of high occupancy vehicle (HOV) facilities. An extensive system of HOV facilities exists in the I-5 corridor between Seattle and Everett. Additions are being implemented or are planned to alleviate the increasing congestion on or near this already heavily utilized freeway. The design of these HOV facilities and the policies governing them depends on the anticipated use of the system. Forecasts provide the basis for planning, project evaluation, and obtaining public support for future improvements to the system.

Despite the importance of accurate mode forecasts, current mode choice methodology is insufficiently responsive to factors that influence shifts to ridesharing modes, particularly TDM policy factors that are important in encouraging commuters to shift from single occupant vehicles (SOVs). Planners and policy analysts need to understand these factors to improve mode shift predictions and evaluate policy changes that can increase vehicle occupancy. The objective of this study is to identify these mode choice factors and use them to improve the ability to analyze HOV policies for the north I-5 corridor.

MODE CHOICE ANALYSIS

The initial objective in this study was to select characteristics of mode choice that were available in the data sets and consistent with current mode choice literature to be used in the analysis. They were grouped into four types: (1) trip characteristics,

(2) "home-end" characteristics, (3) employment site characteristics, and (4) psychological aspects of mode choice.

Two major sets of data were analyzed in this study, both collected by Metro in cooperation with Community Transit. In one study, some 9,324 employees of 23 cooperating businesses were surveyed in north King and urban Snohomish counties. This study is called the "employer-based survey" in this report. The second data set is called the "Transportation Market Segmentation Study of North King and Urban Snohomish County." This was a 1989 telephone survey of a random sample of 3,586 residents in the study area.

The primary objective of this study was to improve the ability to analyze the impact of TDM policies and HOV facilities. Ideally, policy analysts would like to have a **predictive model** of mode choice that can be used to quantitatively forecast the transportation impacts of various alternatives. Most current predictive mode choice models are based on discrete behavioral choice models that use the multinomial logit formulation. One of the goals of this study was to validate a modeling approach developed by the COMSIS Corporation by using similar data from elsewhere in the region.

Other modeling approaches were also investigated. The primary reason for looking at other methods to understand the data is that discrete behavioral choice models based on the logit function have little direct relationship to actual cognitive decision-making processes. Even if a predictive model of mode choice behavior is successful in forecasting mode choice in one situation, it may not be valid in a situation that is different from the one with which it was calibrated. It is important that our understanding of the decision-making process is based on multiple modeling methods, so that we can have some confidence in predictions of mode choice in novel situations. Therefore, a **descriptive model** of mode choice can be very valuable in assessing the transportation implications of alternative TDM polices or HOV facilities.

Logit Analysis

The COMSIS Corporation, located in Maryland, contracted with Metro to develop a model that would accurately reflect the effects of HOV incentives and other workplace conditions on commuter mode choice. COMSIS used employer-based data, similar to that collected for this study, but from employers in the Bellevue CBD and I-90 corridor. A few highlights of the COMSIS findings are as follows:

- carpoolers tended to come from households with the largest number of workers and the fewest vehicles per worker;
- males tended to use transit more than females;
- small flexibility in work hours promoted carpooling, while large flexibility discouraged it;
- free parking was a strong disincentive to transit use and carpooling; and
- bus pass discounts, transportation coordinators and reserved parking for carpools and vanpools were strong incentives for ridesharing.

Two of the objectives of this study were (1) to determine whether a logit model could be calibrated on the data from the employer-based survey in north King and south Snohomish Counties and (2) to compare the results with the COMSIS work that was based on responses from workers in the Bellevue CBD and I-90 corridor.

The logit analysis conducted for this work differed from the COMSIS analysis in some ways that may have affected the comparative results.

- The populations differed. While both study areas were primarily suburban, the COMSIS sample included companies from downtown Bellevue, which is rapidly losing suburban characteristics.
- The variables differed in the two studies. Different information was available in each of the studies.
- The analysis approach was slightly different in the two studies. The COMSIS analysis assessed trade-offs among all six modes at once. This analysis focused on specific comparisons. (A six-mode analysis was conducted for this study, but it revealed no insights that were not apparent in the results reported here.)

Many findings were similar in the two studies. However, there were some substantial differences.

- The number of vehicles per person was not related to mode choice in this study.
- In this study, higher income people were **more** likely to carpool, in contrast to the COMSIS analysis, in which they were less likely to carpool.
- Except for free parking, workplace incentives had less clear relationships with mode choice in this study than in the COMSIS study. Bus pass discounts and reserved parking did not enter significantly into any of the models. The lack of clear relationships may have been due to the fact that they were less salient among the employers in this study's sample than in the COMSIS study's sample.

Other Analysis Conducted for this Study

In addition to the multinomial logit modelling approach used with the employer-based data, other statistical procedures were explored with the telephone survey data to investigate the important factors in model choice. One approach explored the potential for reducing the number of variables needed to explain mode choice through factor analysis. This procedure examines variables for underlying commonalties and groups them into a relatively small number of factors that can provide insight into the basic structure behind the responses. For example, variables that describe the size of the household, the number of household members per worker, or the number of youths in a household may all be combined into one factor called "family characteristics."

Factor analysis provides an idea of the variables that belong together to form major factor groups, and provides a basis for understanding the underlying structure of commuter mode choice. Among the initial variables then, family composition, the perceived need of the car and the ease with which it can be used, commute time, and some measurement of the degree of control desired in one's life, described the major factors. Factor analysis does not identify ways in which individual commuters can be grouped by mode according to these selected variables.

In addition, a second procedure used in this study, cluster analysis, is designed to combine respondents into groups that are "like-minded" and respond similarly to a given set of conditions. If one determines from a cluster analysis, for example, that what characterizes a group of commuters is that they (1) have a strong aversion to feeling out of control and (2) do not tend to ride the bus, one could conclude that these two factors are strongly related.

Two clusters were composed primarily of bus riders, one because members did not have driver's licenses and the other because of strong incentives to use a bus, such as employer-provided subsidies and high parking charges. Two other clusters contained a mix of modes. The Traditional Commuter Cluster was differentiated from the non-Bus-oriented Cluster because members of the cluster tended to have larger families and only one worker in the household. It also turns out that there was a much higher proportion of bus commuting in the first group than the second (hence, the name for the second). Analyses of people who used the same mode to commute to work, but were in different clusters provided insights into likely ways to change mode choice.

SUMMARY AND RECOMMENDATIONS

Many of the findings from this study are important to understanding the nature of mode choice. Some of the results are important for policy recommendations. One of the main objectives of this study was to estimate the relative impact of various TDM measures that can be implemented by employers. Unfortunately, the evidence related to this question was fairly skimpy because the study area contained few examples of employer-provided TDM measures. However, most of the evidence that existed was consistent with other findings. Some of the results may indicate a different emphasis for employer-based TDM measures in a largely suburban area than in a major CBD such as Seattle or Bellevue.

Influence of HOV Lanes

The logit analysis conducted for this study revealed a statistically significant tendency for commuters with HOV lanes along their commute path to choose modes other than driving alone. This is good news for the importance of HOV lanes. However, the cluster analysis showed that commuters who were not already committed to transit or considered highly auto-oriented did not perceive HOV lanes to significantly increase convenience.

One interpretation of these seemingly contradictory results is that HOV lanes do have some influence on mode shift, but that the influence is greater if the system of HOV facilities is more comprehensive. The policy implication of these findings is that the HOV lane system must be more comprehensive before major shifts in mode choice can be generated.

Building a comprehensive system of HOV lanes would increase the HOV-SOV commute time differential, but it would also increase the number of commuters who had HOV lanes along their commute. HOV lanes on major arterials and freeways could assist commuters in areas of lower population and employment density, where adequate transit service might always be economically infeasible.

Workplace Incentives for Ridesharing

Because few incentives for ridesharing were provided by employers in the study area, there was little evidence from the logit analysis to show a consistent relationship between any particular incentive and the tendency to use HOV modes. However, the cluster analysis, which was based on people who resided in the study area and worked in a variety of places, showed that workplace incentives did have a strong influence on mode choice. The existence of a parking charge was especially influential on the use of HOV modes. After that, bus pass subsidies and preferred parking for carpools and vanpools were most highly associated with use of HOV modes to commute to work.

The existence of parking costs was the most consistently present SOV disincentive throughout the mode groupings in the cluster analysis. SOV mode groupings consistently had the lowest parking costs, thus showing a strong correlation between SOV commuting and free parking. Conversely, the bus commuters from the bus-oriented cluster showed the greatest tendency to have to pay parking costs at their work place.

The lack of relationships between workplace incentives and HOV usage among the employers in the study area should not be interpreted as evidence that they are not effective. The fact that many current SOV commuters in the Traditional Commuter Cluster expressed an interest in using other modes and that their attitudes were consistent with using HOV modes indicates that a potential for mode shift is strong, at least among that segment of the commuting population.

Implications of Two-Worker Households

Commuters who came from households with at least two workers were shown in the logit analysis to be more likely to carpool, probably with another member of the household. This result perhaps accounts for the unusual finding that people from higher income households were more likely to carpool than people from lower income households. The explanation is that two-worker households had higher incomes in the study population than households with only one income.

Of the households in the study area, 64 percent had at least two workers. Policy (both public and employer-based) should be designed to take this into account, especially in suburban areas. For instance, day care arrangements should be provided to make carpooling and transit use more accessible and usable by these multi-worker households. In addition, flexible work hours would make it easier for household members to share rides to work.

Use of Cars for Other Purposes

There was a strong tendency in all the analyses for people who indicated a need for a car to run errands to and from work or during work hours to commute to work by themselves. This finding is consistent with results from other studies, but it was especially strong in these data. The strength of the finding may have been related to the suburban setting of the study area, whose services were more spread out and separated from residential areas and places of employment than they are in more densely populated areas.

Two policy recommendations follow from these findings. One is that local jurisdictions should pursue policies that encourage mixed land use, where residences and work places are intermixed with services. Such land use would allow people to conduct some business either on foot or as part of other auto trips.

The second policy is that employers should make company cars available for non-SOV commuters to use for business purposes during the work day. In the cluster analysis, a stronger desire for an employer-provided back-up car differentiated the SOV and pool commuters of the Traditional Commuter Cluster from their counterparts outside the Traditional Commuter Cluster. This service, although very rarely provided by employers in the region, is strongly desired by two of the three mode groups in the Traditional Commuter Cluster.

Mode Choice and Trip Characteristics

Consistent with most other studies of mode choice, the research reported here confirms the observation that longer commute trips are more likely to be made by bus, carpool or vanpool. This is not too surprising, because the longer one travels, the more worthwhile it is to form a pool or spend the time waiting for a bus.

In suburban settings, where parking is free and abundant, converting an SOV commuter with a short commute to a ridesharing mode is highly unlikely. Providing incentives for doing so would likely be very costly and inefficient. Efforts to promote carpooling and vanpooling should concentrate on workers with longer commutes.

For commutes of less than five miles, a more fruitful way to reduce SOV use may be to promote bicycling. Local jurisdictions should provide bikeways or special lanes for bicycles to improve safety. Employers should provide secure places to keep bicycles and provisions for employees to shower and change. It may not be possible to convert many people to consistent bicycle commuting, but even occasional bicycling could have an important impact on pollution and traffic congestion in suburban areas.

Characteristics of People Most Likely to Shift to HOV

From the cluster analysis, one group (the Traditional Commuter Cluster) was identified as most likely to shift from SOV to HOV modes. The others either already tended to be transit users or were committed car users. The people in the likely-to-shift group had the following characteristics:

1. came from larger households,
2. had longer commutes,
3. came from households with working spouses,
4. came from households with students over 16 years of age, or
5. exhibited a weaker "control" factor in their personality.

An increased availability of HOV incentives and SOV disincentives would encourage a mode shift by the members of this cluster to HOV modes.

An analysis of commuters outside the Traditional Commuter Cluster showed that the same characteristics were associated with using carpools to commute.

INTRODUCTION

Transportation demand management (TDM) has received increasing attention in recent years as an important component in approaches to improve the transportation system. Recent legislation has encouraged and, in some cases, required employers and jurisdictions to implement TDM programs. The attention to TDM measures is not expected to diminish in the coming years. Employers and local jurisdictions are very interested in understanding and forecasting the impacts of various TDM options.

Another approach to transportation system improvement is the use of high occupancy vehicle (HOV) facilities. An extensive system of HOV facilities exists in the I-5 corridor between Seattle and Everett. Additions are being implemented or are planned to alleviate the increasing congestion on or near this already heavily utilized freeway. The design of these HOV facilities and the policies governing them depends on the anticipated use of the system. Forecasts provide the basis for planning, project evaluation, and obtaining public support for future improvements to the system.

Despite the importance of accurate mode forecasts, current mode choice methodology is insufficiently responsive to factors that influence shifts to ridesharing modes, particularly TDM policy factors that are important in encouraging commuters to shift from single occupant vehicles (SOVs). Planners and policy analysts need to understand these factors to improve mode shift predictions and evaluate policy changes that can increase vehicle occupancy. The objective of this study is to identify these mode choice factors and use them to improve the ability to analyze HOV policies for the north I-5 corridor.

DESCRIPTION OF THE STUDY CORRIDOR

In general, the study area has fairly low concentrations of employment, with limited public transit service to some business sites. Plentiful free parking exists at most employment centers; although some employment centers, such as both Seattle's and Everett's central business districts and the University of Washington district, have parking congestion and significant parking costs.

Forecasts prepared by the Puget Sound Council of Governments (PSCOG), described in the following section, indicated that the use of the existing transportation system and the level of congestion in the study area will increase no matter what type of facilities are built. After a major recession during 1981-83, the region's economy expanded rapidly and steadily for five years, led by a boom in aerospace production and jobs. During the last couple of years, the region has been somewhat protected from the recession experienced in the rest of the nation. The current plateau is expected to be followed by renewed acceleration of economic growth in the 1990s. Increases in population and total jobs are expected into the decade beginning 2020 (PSCOG, 1988).

SOCIOECONOMIC FACTORS

The following socioeconomic data were derived from the PSCOG's *Population and Employment Forecasts*, 1988.

Population

PSCOG stated that the population of the Puget Sound region in 1988 was 2,550,000; by 2000 will increase 23 percent to 3,148,200; and by 2020 will increase 59 percent over 1988. More specifically for the study area, PSCOG projected that Snohomish County will be the fastest growing county of the region, with a 65 percent increase between 1980 and 2000. By contrast, the adjacent Shoreline Large Area population was projected to increase by 8.6 percent, and the Seattle Large Area by 2.6 percent.

Employment

PSCOG also projected significant increases in employment. In the Puget Sound region the current employment base is 1,329,000 jobs. A 27 percent increase to 1,694,400 jobs is projected for the year 2000, and by 2020, jobs will increase 72 percent over 1988 to 2,286,000. For the study area, PSCOG predicted,

> Substantial increases in jobs will occur in the newer centers, not only in eastern and northern King County, but also in central Everett (Navy base), southwest Everett and the I-5 and I-405 corridors in Snohomish County. . . (p. 21)

PSCOG also predicted a change in the age composition of the population past 2010.

Changes in the age composition of the population will occur in two general phases: until 2010, the proportion of children will decline and the working age will increase; after about 2010, the shares of children and the working ages of the population will stabilize, and the percentage of elderly will increase rapidly. (p. 9)

Trends

The PSCOG framed the above socioeconomic predictions with high and low scenarios. In both scenarios, increases in population and jobs in the Puget Sound region were predicted. The predicted highs were a population of 4,687,800 and employment at 2,642,300 jobs by 2020. The predicted lows were a population of 3,124,400 and employment at 1,760,400 jobs by 2020. The high and low scenarios were described by PSCOG as follows:

> **High** — This trend included an optimistic national forecast, with high exports, low interest rates, low inflation, and high productivity gains. The regional forecast included stable aerospace employment, recovery of shipbuilding with defense contracts, increases in military bases, and a growing federal workforce. The scenario represented an average annual growth rate very close to that of the past 30 years in the region.
>
> **Low** — This trend included the opposite in conditions nationally, with a regional forecast of rapidly falling aerospace employment (to mid-1970s levels), continued decline of shipbuilding, major reductions of military personnel, and reductions in federal civilian staff.

INTERSTATE 5

Peak Hour Traffic Volumes and Capacity Estimates

I-5 is the major north-south transportation corridor of the Puget Sound region. Within the study area, it is an urban, heavily used freeway. It varies from three to four lanes (excluding its HOV system) both north- and southbound. As the region's population has grown, the congestion on I-5 has increased considerably.

PM peak hour data from the Washington State Department of Transportation (WSDOT) (1988), combined with volume-capacity ratios calculated for this study, provided a rough estimation of the degree of congestion on I-5. The PM peak hour is generally found to be the most congested period on any highway facility. A general rule of thumb is that the capacity of a typical freeway lane is 2,000 vehicles per hour (Legg, 1990). This rule was used to estimate the volume-capacity ratios listed in Table 1. This table excludes HOV lane and Express lane volumes in measuring congestion. To enable

Table 1.

Volumes and Volume/Capacity Ratios for Interstate 5

	No. of Lanes Each Roadway	Average Hourly (AWD/24 HRS)		PM Peak Hour		Estimated PM Peak Hour V/C Ratio
		NB	SB	NB	SB	
AT SHIP CANAL BRIDGES	4	4058	4580	7680	7270	0.961
SOUTH OF 130TH ST NE*	4	3656	3595	7975	5180	0.997
SOUTH OF 205TH ST SW	4	2841	2975	6710	4490	0.839
AT 164TH ST SW	3	2559	2560	5760	5330	0.888
AT 128TH ST SW	3	2313	2648	4860	5360	0.893

AWD = AVERAGE WEEKDAY VOLUMES
V/C RATIO = VOLUME/CAPACITY RATIO
NB = NORTHBOUND
SB = SOUTHBOUND

*NB PM peak hour excludes 550 vehicles on HOV lane (estimated from SB AM peak hour HOV lane statistics provided by Les Jacobson, WSDOT Project Manager, for 1988).

Source: Washington State Department of Transportation (WSDOT), Ramp and Roadway Traffic Volumes, 1988, and HOV lane statistics provided by Les Jacobson, WSDOT Project Manager, for 1988.

HOV lanes to provide the fast commute times that are the incentive for commuters, they are designed to operate below capacity, even during the peak hour. Inclusion of this HOV lane data would have skewed the accurate measurement of congestion. Off-ramp volumes were included when WSDOT volume data were collected at an interchange.

Although volume-capacity ratios are a rough indicator of highway congestion, they are influenced by many factors that are not easily reflected in a simple number. The relationship between vehicle density and volume on a highway is a simple mathematical one until the road reaches high levels of congestion. At that point, the relationship becomes unstable, and it is impossible to confidently predict average travel speeds on the basis of the traffic volume.

Table 1 indicates that I-5 is indeed a heavily used facility. It is becoming less and less capable of withstanding increasing traffic volumes. Volume-capacity ratios are all above 0.800. Most areas have four lanes, which decline to three lanes just north of the King County - Snohomish County line. Northbound p.m. peak hour volumes are larger than southbound volumes, but the differential between southbound and northbound p.m. peak hour volumes declines at the data collection sites nearer Everett. At 128th Street SW, the southbound volume exceeds the northbound volume during the p.m. peak hour, unlike other sites reported in the study. This indicates traffic flow from areas of high employment density near Everett to outlying residential areas. The highly congested Ship Canal Bridge near downtown Seattle shows high volumes both north- and southbound during the p.m. peak hour. This bridge is the bottleneck of I-5 in the Seattle area.

<u>Average Occupancy</u>

Data collected by WSDOT (May 1987) revealed an average occupancy of 1.2 persons per vehicle in the four south- and northbound general purpose lanes at Northgate Way during the morning and evening peak hour. During the same data collection effort, the HOV lane at that intersection yielded an average occupancy of 7.45 persons per vehicle northbound and 6.21 persons per vehicle southbound during the peak hour. In 1985, a similar WSDOT survey yielded similar results with an average of 1.2 occupants per vehicle in the general purpose lanes and 6.5 persons per vehicle northbound and 7.2 persons per vehicle southbound in the HOV lanes (WSDOT, 1985).

PARALLEL ARTERIALS

Because I-5 is heavily used and nearing capacity, it is important to assess the ability of parallel arterials to carry corridor traffic. To perform that assessment, the parallel arterials were identified and their volumes and capacities were analyzed.

Parallel arterials were selected for analysis on the basis of the probability that they would be used by I-5 commuters to avoid freeway congestion. Figure 1 provides a map of their locations. They are listed in Table 2 from north to south, from Everett city center to Seattle city center.

Table 3 provides average hourly volumes (derived by dividing the average weekday traffic volume by 24), PM peak hour volumes, and estimated volume-capacity ratios for some of the parallel arterials at selected screen lines. The data were collected from the engineering departments of the City of Seattle, King County, Snohomish County, and WSDOT. Because of jurisdictional variation in the kinds and amounts of data, data were sufficiently consistent to provide a meaningful comparison only at some sites.

The volume-capacity ratios were derived from formulas in the 1985 Highway Capacity Manual. These ratios are a function of roadway width, configuration, location, and intersection signal lighting patterns. To give a general indication of the level of congestion, "screen lines" were selected that were perpendicular to the general north-south traffic flow on I-5. From south to north, the screen lines selected were the Ship Canal bridges, the Seattle city limits at 145th Street, the County line at 205th Street, 164th Street in Snohomish County, and one site for SR-99 near Paine Field. These correspond roughly with the volume data collection sites reported in Table 2 for I-5.

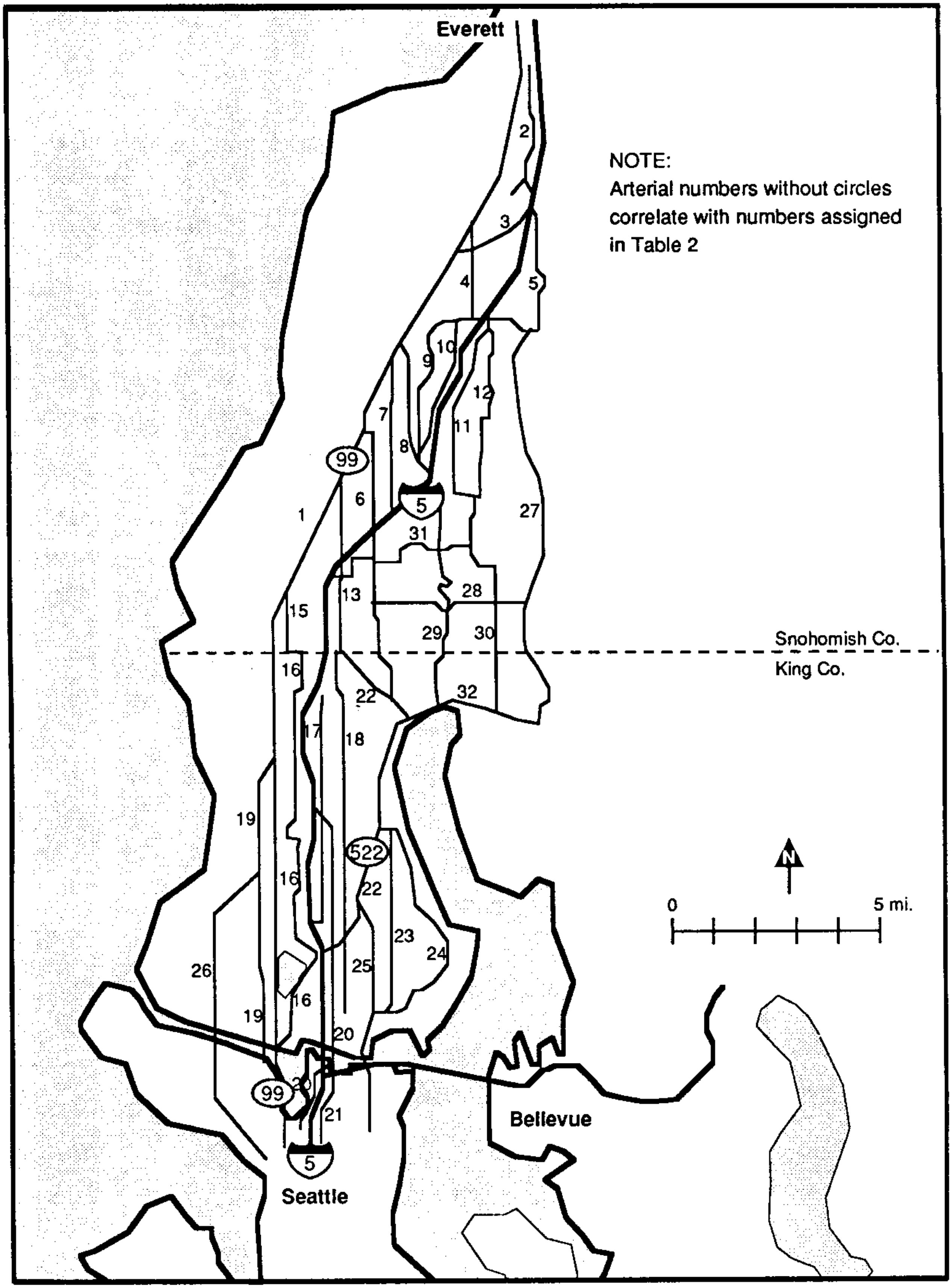

Figure 1. North I-5 and Parallel Arterials

Table 2.

Arterials Parallel to Interstate 5

#	Parallel Arterial	From	To
1	Evergreen Way/SR-99	Everett CBD	Seattle CBD
2	Colby Ave./Casino Rd.	41st St.	Broadway
3	Broadway	Hewitt Ave.	Everett Ml. Wy.
4	Fourth Ave.	SR-526	128th St. SW
5	SR-527/19th Av.	SR-526	132nd St.
6	44th Ave. W/Cedar Wy.	168th St. SW	SR-104
7	35th/36th Ave. W	148th St.	I-5
8	SR-525	SR-99	I-5
9	Manor Way	128th St. SW	SR-525
10	Ash Way	128th St. SW	SR-525
11	Meadow Rd./10th Ave.W	128th St. SW	Filbert Rd.
12	Cascadian Wy./North Rd.	128th St. SW	Filbert Rd.
13	52nd Ave. W/56th Ave. W	SR-99	SR-104
15	76th Ave.	SR-99	205th St. SW
16	1st St./Meridian/Greenlake Wy.	205th St SW	SR-99
17	5th Ave. NE	185th St.NE	85th St. NE
18	15th Ave. NE	SR-104	Pacific St. NE
19	Greenwood/Phinney/Fremont Ave. N	SR99@155th	SR99@Fremont Br
20	Roosevelt Way NE/Eastlake	125th St. NE	Mercer St.
21	10th/Broadway	Eastlake	Denny St.
22	SR-104/Lake City Wy.	I-5 @ 205th	I-5 @ 75th NE
23	35th St. NE	125th St. NE	45th St. NE
24	Sand Pt. Wy./Montlake	125th St. NE	45th St. NE
25	25th Ave. NE	Lake City Wy.	45th St. NE
26	Holman Rd. NW/15th Ave. W.	Greenwood Ave.	Seattle CBD
27	Bothell-Everett Hwy.	132nd St.	SR-522
28	228th St. SW	Bothell Hwy.	44th Ave. W
29	Cypress Wy./Locust Wy.	Filbert Rd.	SR-522
30	Damson Rd./Meridian Av.	Filbert Rd.	SR-522
31	Logan Wy./Larch Wy. W/220th St. SW	Damson Rd.	I-5
32	SR-522	Bothell Hwy.	Lake City Wy.

Table 3.

Volumes and Volume/Capacity Ratios for Selected Parallel Arterials at Selected Screen Lines

No.	Arterial	Average Hourly (ADT/24 HRS) NB	SB	p.m. Peak Hour NB	SB	Estimated p.m. Peak Hour V/C Ratio
	AT SHIP CANAL BRIDGES					
1	AURORA BRIDGE	1372	1431	4954	2731	0.986
19	FREMONT BRIDGE	544	586	1895	1205	0.804
26	BALLARD BRIDGE	1062	1034	3156	1687	0.904
20	UNIVERSITY BRIDGE	626	605	1729	1422	0.516
24	MONTLAKE BRIDGE	1171	1209	2422	2211	0.723
	AT 145TH STREET					
1	SR99-AURORA	707	742	1764	1203	0.624
16	MERIDIAN	91	84	538	161	0.536
19	GREENWOOD	498	491	1708	779	0.725
17	5TH AVE NE	97	158	1507	184	0.639
18	15TH AVE NE	330	317	1146	571	0.486
22	SR104-LAKE CITY WY	752	818	2010	1121	0.711
	AT COUNTY LINE (205TH ST)					
1	SR99-AURORA	736	746	1710	1180	0.726
16	MERIDIAN	199	200	630	300	0.301
18	15TH AVE NE	216	207	760	340	0.403
6	CEDAR WAY	n/a	n/a	182	426	0.271
	AT 164TH STREET					
1	SR99 @ 35TH AVE W	823	752	1610	1720	0.730
7	35TH/36TH AVE W	n/a	n/a	370	265	0.548
10	ASH WAY	n/a	n/a	225	142	0.598
11	MEADOW RD/10TH AVE W	n/a	n/a	338	36	0.764
	SOUTH OF PAINE FIELD					
1	SR99 @ AIRPORT ROAD	678	636	1360	1560	0.828

n/a = not available
ADT = Average daily traffic volumes
NB = Northbound
SB = Southbound
V/C RATIO = Volume/capacity ratio

Sources: Engineering Departments for City of Seattle, King County and Snohomish County, and WSDOT Traffic Studies Office, 1987 - 1989 data.

Some assumptions were employed to allow the computation of parallel arterial capacities. Because of insufficient data availability, a "60 percent green light" factor was used in calculating the capacities of all the parallel arterials (Legg, 1990). However, according to Jacobson (1990), when an intersection must handle significant left-turning traffic volumes, the green light percentage may be as little as 25 to 30 percent. This may have skewed the capacities of SR-99, 5th Avenue and Meridian at 145th Street NE, Meridian and 15th at 205th Street N, and Lake City Way at SR-104. Congestion at these intersections is probably greater than the volume-capacity ratios indicate.

Despite these data constraints, the data plainly showed that where traffic funnels across the bridges into the central business district (CBD) of Seattle the greatest congestion occurs. Montlake Bridge deserves special mention because reported PM peak hour volumes were larger for northbound traffic than southbound, despite the fact that significant volumes of traffic leave the University District to access SR-520 and other points south.

The data also showed that during the PM peak hour, major arterials such as SR-99, and not some of the lesser arterials, carry the bulk of the congestion diverted from I-5. Some capacity does seem to be available in these lesser arterials, and it will likely be used by commuters as congestion on I-5 becomes more intolerable. The local jurisdictions may have to decide whether this congestion is appropriate for these roadways and balance the need of the commuters for enhanced travel times with the desire of the residents near the arterial to maintain the arterials' residential character.

THE HOV SYSTEM

HOV systems can produce major benefits for a transportation system. They have been shown to produce significant increases in travel speed and cost savings. In a cost-benefit study of Interstate 5 (I-5), Ulberg (1987) estimated peak hour speed differences between HOV and SOV users of 11 mph in 1985 and 20 mph in 2000. His analysis also estimated average peak hour time savings for carpoolers of over 4 minutes in 1985 and 9 minutes in 2000. Each $1 spent to implement HOV lanes returned at least $9 in benefits. These benefits resulted in an annual savings per commuter of $140 to $600 per year.

HOV systems contribute significantly to increasing energy efficiency. Comparative efficiencies of HOV vehicles were analyzed by Geller, Winett and Everett (1982). They found that vanpools were the most energy efficient, express buses second, and older subways third. Vanpools were almost six times more efficient than single occupancy vehicles in British Thermal Units (BTUs) per passenger mile. The efficiency of carpools increases approximately linearly with the number of passengers.

HOV Lanes

The heart of the I-5 HOV system is the network of HOV lanes (see Figure 2[1]). I-5 has 15.6 completed miles on the mainline and in the Express Lanes (PSCOG, 1989). These extend northbound from Cherry Street in downtown Seattle to 175th NE, and southbound from 236th Street SW to NE Northgate Way (WSDOT, 1988). Additionally there are small stretches of HOV lanes on arterials parallel to I-5: SR-522 has a 0.62-mile section northbound between 135th and 147th, a 2.06-mile section southbound from the Kenmore Park and Ride (73rd NE) to Ballinger Way, and a 1.5-mile section between 115th and 145th on SR-99 (WSDOT, 1989).

HOV lanes are proposed or under construction on southbound I-5, Mercer Street to Yesler Way and northbound from South Lucille Street to Jefferson Street. Subject to funding availability, WSDOT has scheduled the following for construction: (1) SW 236th Street to Swamp Creek (to be bid in March 1993) and (2) Ship Canal to Lake City Way (to be bid in November 1991) (PSCOG, 1989).

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[1] Source: *Puget Sound Council of Governments, HOV Task Force, Preliminary Report on High Occupancy Vehicle (HOV) Facilities and Activities*, February, 1989.

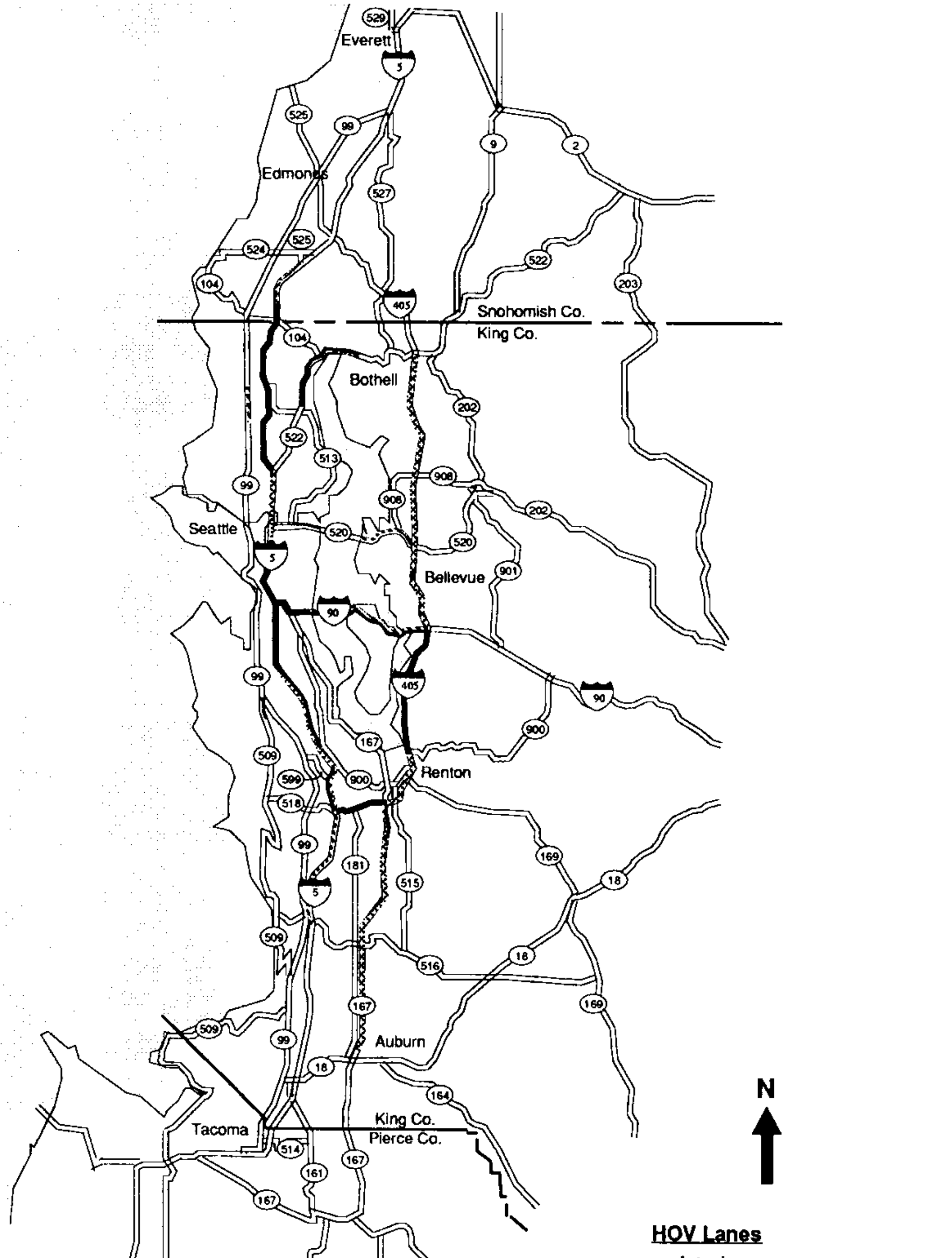

Figure 2. HOV Lanes in North I-5 Corridor

Related HOV Facilities

Also included in the north I-5 HOV system (see Figure 3) are metered bypass ramps, transit freeway stations, and transit centers. Meter-bypass ramps are located southbound at 164th Street SW, 196th Street SW, 220th Street SW, 236th Street SW, NE 205th Street, NE 175th Street, NE 130th Street, NE 85th Street, and NE 45th Street. Northbound, one bypass ramp is located at NE 45th Street. Freeway transit stations are located at 205th Street, NE 145th Street, and NE 45th Street. Metro has a regional transit center at Aurora Village and one under construction at Northgate (PSCOG, 1989).

Metro Transit Bus Service

Metro provides an extensive system of bus routes for commuters throughout north King County. Some of the major routes carry over 2,300 passengers between 6 AM and 6 PM during the weekdays (Metro, 1989). Many routes radiate from the Seattle CBD to outlying areas, and another concentration of routes radiate from the University district. Major outlying routes in north King County are often less frequent than hourly, although many heavily used express buses travel via I-5 to the Seattle CBD and the University of Washington. Table 4 provides a sampling of the ridership from some of the major north King County routes for the fourth quarter of 1989. The average number of riders per trip for all routes is 31.6 (Metro, 1989).

Community Transit Bus Service

Community Transit provides transit services for commuters throughout Snohomish County and to major employment centers throughout the Puget Sound Region, including the University District and the Seattle CBD. Many routes originate from park and ride lots in the Snohomish County section of the north I-5 corridor. Table 5 provides a sampling of the ridership from some of the major Community Transit routes for March, April, and May of 1990.

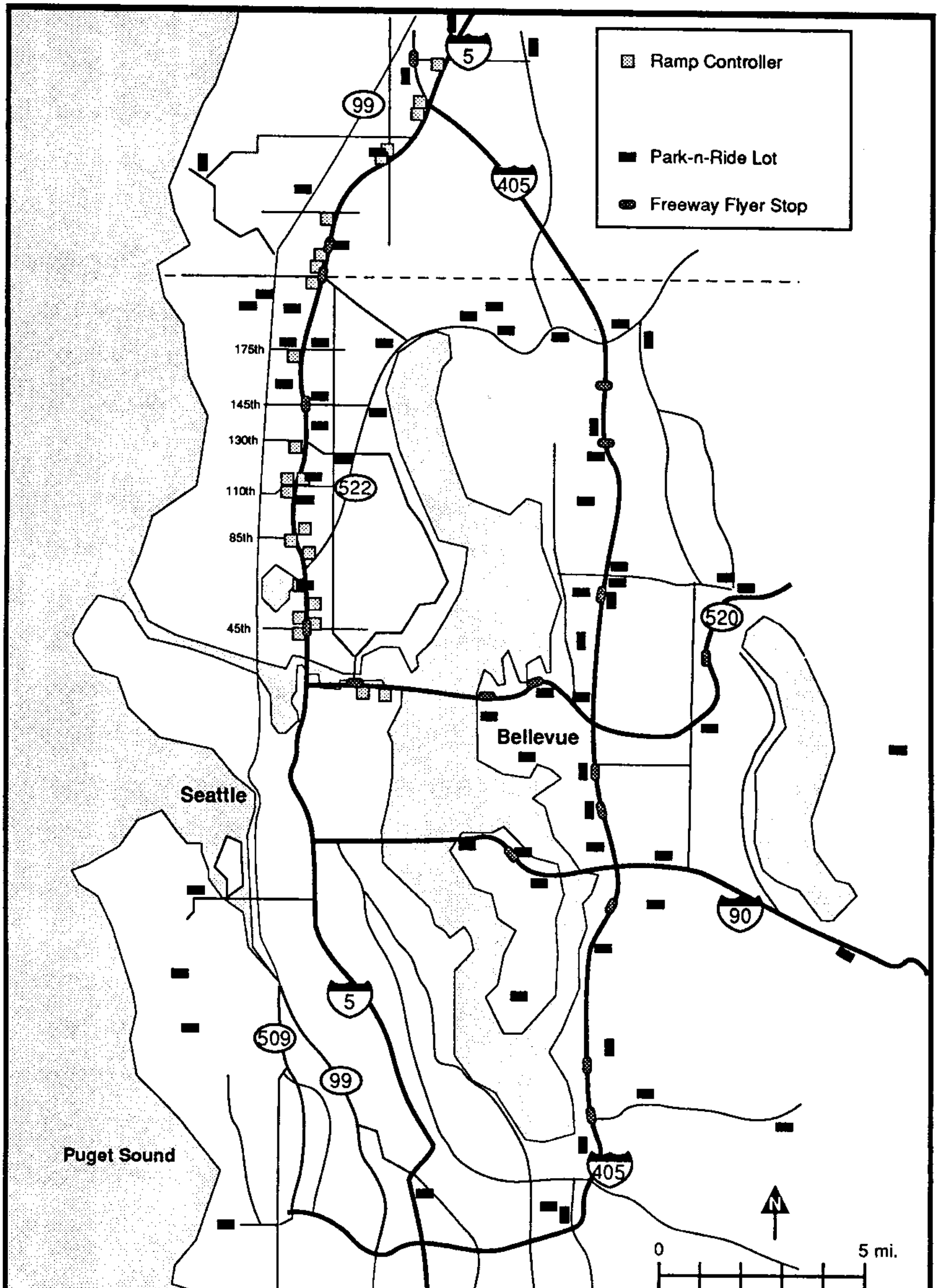

Figure 3. Related HOV Facilities

Table 4.

Selected Major Metro Routes in North King County
Weekdays 6 a.m. to 6 p.m. (Daily Figures)

Route	Description	No. of Trips	Total Riders	Riders/Trip
6	Downtown	54	2207	40.9
72	University/Downtown	47	2309	49.1
73	University/Downtown	54	2396	44.4
301	Downtown	23	869	37.8
307	Northgate/Downtown	86	1754	41.8
317	Northgate	12	347	28.9
340N	University	34	734	21.6
340S	University	56	2189	39.1
355	Downtown	55	1716	31.2
377	Downtown	15	479	41.8

Source: Municipality of Metropolitan Seattle (METRO), Computer Print-out, "Route Productivity by Route," October, November, December, 1989.

Table 5.

Selected Major Community Transit Routes in the North I-5 Corridor for March, April, May, 1990
Weekdays Only (Quarterly Totals)

Route	Description	Total Trips	Total Riders	Riders/Trip
170	Suburban	2080	58,566	28.2
750	Suburban	4680	86,945	18.6
210	Rural (north)	2795	49,118	17.6
850	University of Washington	3055	69,690	22.8
401	Seattle	2275	95,990	42.2
403	Seattle	910	36,125	39.7
411	Seattle	1883	74,535	39.6

Source: Community Transit, Computer Print-out, "Community Transit Ridership Data," March, April, May, 1990.

Park and Ride/Park and Pool Lots

Park and ride/park and pool lots that assist commuters in the north I-5 corridor are provided by both Metro and Community Transit at 17 sites in King County and eight sites in Snohomish County. The number of parking spaces and utilization rates are listed in Table 6. The table shows that lots located further from the Seattle CBD and that are close to I-5 generally have higher utilization rates.

Ramp Control

Related to the I-5 HOV system is WSDOT's FLOW system. One of FLOW's elements is ramp metering, which improves highway efficiency and reduces congestion. It also encourages shift to HOV by providing bypasses for vehicles other than SOV.

Another element of FLOW is the Surveillance Control and Driver Information (SC & DI) System, which gathers information about the condition of the freeways with electronic surveillance and disseminates this information to the public through graphic display, highway advisory radio, and radio stations in the area (Jacobson, 1989).

TDM MEASURES

TDM measures, which include just about anything that encourages the use of the HOV system, are critical to the efficient functioning of the transportation system. Throughout the U.S. there are many examples of major successes with TDM measures. The U.S. Department of Transportation (USDOT, 1989) reported examples of several successful programs. Pacific Northwest Bell in Bellevue, Washington, reduced solo driving from 87 percent to 19 percent of the work force through a combination of TDM measures. Similarly, Commuter Computer in Los Angeles reduced its SOV (single occupancy vehicle) share from 42 percent to 8 percent by eliminating free parking. In another survey of TDM programs, Kuzmyak and Schreffler (1989) analyzed the effectiveness of some TDM programs implemented around the U.S. They found that the programs reduce the number of vehicle trips by an average of over 20 percent. This level of trip reduction can have a significant effect on congestion in a metropolitan area.

Table 6.

Metro and Community Transit Park and Ride Lot Utilization
Metro (North King County)
October, November, December, 1989

Name of Site	Location	Spaces	Utilization
Shoreline	SR99/N192nd	384	100%
Bethel Lutheran	NE175/10thNE	50	66
Shoreline Christian	NE148/1stNE	37	59
Fifth/145th	5thAveNE/NE145	68	90
Fifth/133rd	5thNE/NE133	47	30
Northgate	5thNE/NE112	512	100
North Seattle	1stAveNE/NE100	140	84
Greenlake	I-5/NE65th	266	80
Our Savior Lutheran	NE125/27thNE	21	33
Lake City Elks	145th/LkCtyWy	54	46
Bethany Baptist	NEBothlWy/62NE	40	75
Northshore	68NE/NE182nd	376	15
Kenmore	SR-522/73NE	432	83
	Total	2,427	
	Average:	186	60%

Metro and Community Transit Park and Ride Lot Utilization
Community Transit (Study Area Only)
October, November, 1989 and January, 1990

Name of Site	Location	Spaces	Utilization
Montlake Terrace	I-5/236St SW	394	99%
Edmonds	72W/213thSW	255	66
Lynnwood	46thW/213PlSW	808	99
Edmonds	9th/Hindley	48	**
Swamp Creek	164th/SR525	400	95
Mariner	132SW/4thAvW	410	104
Silver Lake	21st/132StSW	107	**
Peace Church	19th/Burley	25	**
	Total:	2,447	
	Average	306	93%

Sources: Mike Wong, Metro Capital Facilities Planner, telephone conversation, March 27, 1990 and, John Layzer, Community Transit Capital Facilities Planner, telephone conversation, May 11, 1990.

**Indicates data not available

In the study area, TDM measures are provided largely by public transit agencies, WSDOT, and to a lesser extent, by employers. The measures include ridematching and ridesharing services; marketing efforts; the HERO program, which allows motorists to report HOV lane violators; traffic information; bus and vanpool subsidies; and city ordinances and business policies concerning parking control (PSCOG, 1989).

TDM Programs Recommended by Metro

Metro, in coordination with PSCOG, has published recommendations for local jurisdictions to establish ordinances that would require employers to establish transportation demand management (TDM) programs. The following is a compilation of their recommendations, as presented in *Transportation Demand Management Policy Guidelines* (1989):

Small projects (25-49 employees)	Appointed transportation coordinator Pedestrian and bicycle amenities Transit/rideshare information Preferential HOV parking Alternative work hours Surveys and monitoring
Medium size projects (50-149 employees), add:	Financial subsidy ($15 per month minimum) Commuter information center
Large Projects (150+ employees), add:	Parking fee program (discount for HOVs) HOV road improvements Van/shuttle bus to park and ride lots or transit Land for transit facility Guaranteed ride home program

Existing Employer-based Services

In the Metro employer-based survey of 24 employers in the north I-5 corridor, only three had any programs to promote the use of transit and ride-sharing (McCutcheon, 1989). Some employers did have some aspects of a TDM program in place. These ranged from Microsoft, with a 5 percent full-time equivalent transportation coordinator, bus pass subsidy, ridematch services, rideshare information, and bike facilities, to smaller businesses with none of the TDM services. Boeing, by far the largest employer surveyed, had a 20 percent rideshare goal, vanpools, rideshare information, a transportation fair, and bicycle facilities. All employers offered free parking that essentially covered the demand. Three businesses responded that some employees parked off-site, but none felt their employees had to pay for the parking.

These results contrast with the Seattle CBD and the University of Washington district, which have significant parking costs and parking congestion. Additionally, the University of Washington has a strong TDM program, which consists of a majority of the TDM measures recommended by Metro.

SELECTED CHARACTERISTICS OF MODE CHOICE

The initial objective in this study was to select characteristics of mode choice that were available in the data sets and consistent with current mode choice literature to be used in the analysis. They were grouped into four types: (1) trip characteristics, (2) "home-end" characteristics, (3) employment site characteristics, and (4) psychological aspects of mode choice.

TRIP CHARACTERISTICS

Commute Time and Distance

The evidence that travel time is the most important aspect in mode choice has been generally supported by research. McGillivray (1970) found that travel time is always more important than travel cost in affecting mode choice. Paine, Nash, Hille and Brunner (1969) found that the largest difference in satisfaction between auto and bus is related to travel time. Horowitz and Sheth (1977) found that time loss is the most important deterrent to people's choice of carpooling as a travel mode.

Obviously, commute time is closely related to the distance of the commute. However, it is not directly correlated, because congested roads may make certain commutes longer than other commutes, despite a shorter distance. Different modes also have different commute times and distances for the same household because of HOV lanes, mode accessibility, or logistics, as in the case of gathering individuals for a car or vanpool.

Researchers have found that perceived travel time (and likely distance) is more critical than actual travel time and have urged the use of perceived time values in modeling mode choice. Spear (1976) discovered that perceived time better predicts mode choice than does actual time. Dobson and Tischer (1977) compared three different models for mode choice by using (1) actual times and costs, (2) perceived times and costs, and (3) demographic variables. The second model performed better than either of the other two or a combination of the other two.

Travel Costs

Researchers have had mixed results in determining the importance of travel costs in mode choice. Henley, Levin, Louviere, and Meyer (1981) found that car users are generally inaccurate in estimating the full cost of driving a car to and from work, and tend to underestimate the fixed-plus-operating costs of using a car in comparison to taking the bus. Dobson and Tischer (1977) demonstrated that perceived costs work better than actual costs in predicting mode choice. As an example of this, Westin and Watson (1975) found that 90 percent of the people in their survey included only gas and oil in their estimates of costs, despite the fact that costs of vehicle operation and ownership far exceed these two items.

The literature shows that parking costs are especially important in mode choice. Shoup (1982) estimated that at least 20 percent of all those who park free and are SOV commuters would switch to a rideshare mode if they had to pay for parking. He showed that for most commuters, free parking is a larger financial incentive than free gasoline. He further estimated that nationwide, 93 percent of all commuters park free at work (Shoup, 1980). Feeney (1989) also expressed the view that parking policy measures (which include parking costs and parking taxes) are a relatively important influence on modal choice.

The Gilmore Research Group (1989), which researched one of the sets of data used in this study, found that of the urban Snohomish County commuters interviewed, 36 percent of the bus commuters parked free when they drove to work, whereas 92 percent of the SOV commuters paid nothing to park. Bus commuters paid an average of $5.05 per day when they drove, while SOV commuters averaged $2.50 per day. In comparison, for north King County, they found that only 10 percent of bus commuters parked free when they drove to work, whereas 84 percent of SOV commuters paid nothing to park. Bus commuters paid an average of $5.18 per day when they drove, while SOV commuters averaged $2.43 per day.

HOME-END CHARACTERISTICS

These attributes are related to the characteristics of the household and its members. The attributes used for the research included a variety of demographic factors, such as size of household, number of workers per household, ages of household members, income, educational levels, and the like.

However, there is some evidence that individual demographic factors are not important in themselves. For instance, Ulberg (1989) stated,

> Research on the influence of sociodemographic characteristics of individuals and households on mode choice has had mixed results. However, one theme runs through the literature. The most important characteristic is automobile accessibility in a household. All other demographic variables appear to operate through this one. To the extent that those factors influence auto ownership, the number of auto users in the household and the household's decision rules for use of the auto(s), they affect mode choice.

If a family has two or more workers in the household and only one car, obviously some of the workers will have to find modes other than an SOV. Similarly, if a household has one auto and one or more young children with day care needs, the mode choices of individuals will be severely constrained.

The type of household dwelling owned by a commuter may have an important relationship to mode choice. Although this factor has not been explored in previous research, it was examined in this study to test the hypothesis that home ownership has an influence on mode choice. This hypothesis is based on the assumption that renters can more easily relocate near a new job location and reduce commute time than home owners can purchase housing near a new job.

EMPLOYMENT SITE CHARACTERISTICS

Characteristics of mode choice associated with the commuter's employment site that were investigated included the following:

- errand need (both personal and work-related),
- schedule flexibility,
- arrangements for emergencies, and
- other employer policies to encourage HOV use.

Errand Need

McCutcheon (1989) found that north King County and urban Snohomish County commuters who rarely or never need their car at work during the day or for errands on the way to and from work are less likely to commute by SOV. Perceived errand need was therefore included in the initial analysis for this study.

Schedule Flexibility

Another characteristic of commuters that appeared to be correlated with mode choice was the degree of flexibility one had in one's work schedule. McCutcheon (1989) found that

> . . . those with variable hours are the most likely to use travel by SOV. When hours are fixed and regular, by either the employees or the employer, the commuter is more likely to use carpools, vanpools, or ride the bus.(p. 12)

Arrangements for Emergencies

One factor that has been postulated to discourage SOV commuters from using HOV commute methods is the inability to get home in case of an emergency. McCutcheon (1989) found emergency backup cars to be the most popular new service desired by commuters. Of the people she interviewed, 40 percent answered that they definitely or probably would use this service. Although popular, very few employers provide such a service. None of the 23 employment sites used in this study had such a service.

Other Employer Policies to Encourage HOV Use

Employers in the study area have begun to employ a variety of transportation demand management (TDM) methods designed to encourage employees to shift from SOV to HOV modes to commute to work. They include parking policies such as charging for parking or providing preferred parking for carpools and vanpools. Subsidies for bus passes or vanpool use are available at many companies. Some larger companies provide special ridematching services for their employees.

PSYCHOLOGICAL CHARACTERISTICS

Another important category of mode choice characteristics is based on the psychological aspects of decision-making and mode choice. These psychological aspects are related to an individual's decision-making style and belief system.

The way in which an individual approaches a particular decision-making task is more complex than a simple weighing of the pros and cons of each mode. A large body of research in both transportation and psychology supports this conclusion; details may be found in a literature review by Ulberg (1989). Intangible factors such as value systems can have a strong influence on the decision-making process. For instance, Hogarth (1980) stated that the decision-making task environment is affected by memory capacity and each individual's schema or belief system, among other factors. Tischer and Phillips (1979) found a strong, mutually causative relationship between the belief structure and behavior for both SOV and bus users. The literature suggests that commuters probably make decisions on the basis of a limited number of factors, which are not always logical, that confirm their existing behavior and reflect their belief system.

Unfortunately, measuring these psychological aspects of mode choice in a survey can be a difficult and complex endeavor. However, a few variables included in the data used in this study relate to these psychological factors. They include questions about discomfort around strangers and discomfort when learning something new. These are include in the analysis reported below.

SOURCES OF DATA

Two major sets of data were analyzed in this study, both collected by Metro in cooperation with Community Transit. In one study, some 9,324 employees of 23 cooperating businesses were surveyed in north King and urban Snohomish counties. This study is called the "employer-based survey" in this report.

The second data set is called the "Transportation Market Segmentation Study of North King and Urban Snohomish County." This was a 1989 telephone survey of a random sample of 3,586 residents in the study area.

EMPLOYER-BASED SURVEY

The employer-based survey targeted companies with 50 or more employees in north King County and urban Snohomish County. From an initial list of 38 companies, 23 cooperated in the study. The response rate by company varied from 0 percent to 89 percent, with a mean of 30 percent (McCutcheon, 1989). The total number of respondents was 9,534.

McCutcheon identified bias among the respondents toward white collar employees, who were 69 percent of the total sample. She explained that some companies were operating with extensive overtime and would not allow employees to fill out the questionnaire during work hours, thus likely reducing the response rate for those companies. Also, the questionnaire required a literacy level that may have deterred foreign-born workers or those with educational deficits.

Another factor that may indicate a bias toward white collar workers was that the median household income of respondents was $42,248. In contrast, PSCOG estimated that the 1987 median household income for King County at $28,930 and for Snohomish County at $27,880.

Additionally, McCutcheon mentioned great variability in the support of management toward administering the questionnaire. Some contact persons had little or no time to devote to the survey.

TELEPHONE SURVEY

This survey was conducted for Metro by Gilmore Research Group. It consisted of 3,586 telephone interviews conducted in 1989 among a random sample of north King County and urban Snohomish County residents. Of the 3,586 respondents, 3,063 were urban Snohomish County residents and 523 were from north King County. On the average, the interview took 27 minutes to complete. Telephone numbers were selected through random-digit dialing.

The sample was stratified by mode to provide enough interviews to ensure statistical reliability for each mode subgroup. The sample contained 2,949 commuters. Data in Table 7 were derived using variables measuring typical commute mode and the number of people in the car, to determine typical modes or mode combinations.

SOV commuters made up 61.9 percent of the commuters. These were respondents who answered that they typically used the "car/drive" method of commuting with one person in the car. Those with greater than one person in the car were considered a carpool. The "OTHER" category included those who traveled by bicycle, motorcycle, foot, or any other miscellaneous mode.

The original mode categories were recoded for the cluster analysis of this study and simplified into four groups:

- SOV;
- BUS, composed of BUS, SOV/BUS, BUS/VANPOOL and BUS/OTHER;
- POOL, composed of CARPOOL, VANPOOL, and SOV/VANPOOL; and
- OTHER, composed of OTHER and OTHER/SOV.

Table 7.

Typical Mode or Mode Combinations
Metro Telephone Survey

Typical Mode	Frequency	Percent	Valid Percent
SOV	1829	51.0	61.9
BUS	209	5.8	7.1
CARPOOL	587	16.4	19.9
VANPOOL	26	0.7	0.9
OTHER	59	1.6	2.0
SOV/BUS	129	3.5	4.3
SOV/VANPOOL	4	0.1	0.1
SOV/OTHER	89	2.5	3.0
BUS/VANPOOL	1	0.0	0.0
BUS/OTHER	18	0.5	0.6
TOTAL COMMUTERS	2949		
REFUSED	5	0.1	0.2
NON-COMMUTER	632	17.6	—
TOTAL	3586	100.0	100.0

ANALYSIS AND MODEL DEVELOPMENT

The primary objective of this study was to improve the ability to analyze the impact of TDM policies and HOV facilities. Ideally, policy analysts would like to have a **predictive model** of mode choice that can be used to quantitatively forecast the transportation impacts of various alternatives. Most current predictive mode choice models are based on discrete behavioral choice models that use the multinomial logit formulation (discussed in more detail below). One of the goals of this study was to validate a modeling approach developed by the COMSIS Corporation by using similar data from elsewhere in the region.

Other modeling approaches were also investigated. The primary reason for looking at other methods to understand the data is that discrete behavioral choice models based on the logit function have little direct relationship to actual cognitive decision-making processes.[2] Even if a predictive model of mode choice behavior is successful in forecasting mode choice in one situation, it may not be valid in a situation that is different from the one with which it was calibrated. It is important that our understanding of the decision-making process is based on multiple modeling methods, so that we can have some confidence in predictions of mode choice in novel situations. Therefore, a **descriptive model** of mode choice can be very valuable in assessing the transportation implications of alternative TDM polices or HOV facilities.

MULTINOMIAL LOGIT MODEL

The commute decision is a "discrete" choice. In other words, a choice to use a mode is not made along a continuum but among a finite number of distinct alternatives. A commonly used discrete choice model is called a multinomial (meaning many choices) logit formulation. For each decision-maker, the logit formulation produces a set of

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[2] See Ulberg (1989) for a further discussion of this assertion.

probabilities. The mode choice with the highest probability is that which has the highest "attractiveness" in relation to the combined attractiveness of all the other mode options. This modeling approach was investigated for this project.

COMSIS Modeling Work

The COMSIS Corporation, located in Maryland, contracted with Metro to develop a model that would accurately reflect the effects of HOV incentives and other workplace conditions on commuter mode choice. COMSIS used employer-based data, similar to that collected for this study, but from employers in the Bellevue CBD and I-90 corridor.

The basic logit structure assumes that an improvement in the attractiveness of one alternative is equally likely to draw commuters from each of the other alternatives. However, COMSIS speculated that modes were probably "grouped." That means, for instance, that some commuters were more likely to shift among transit modes, and others among carpooling modes. A nested, rather than the basic. logit model represents this tendency. For this reason, COMSIS included the nested model among those to be tested in the analysis of the Seattle CBD commuter data (COMSIS, 1989).

The COMSIS model included the physical characteristics of the commute faced by each commuter who lived in a particular area for a particular employment site. These characteristics included variables such as calculated commute times (including in-vehicle and out-vehicle time) for each mode, commute costs, and estimated parking costs. Employment site characteristics included how working hours were set, the worksite's employment density, and employer-based incentives. Commuter characteristics included in the model were number of workers per household, occupation, income, and gender.

The results of the COMSIS model calibration are presented in detail elsewhere (COMSIS, 1990). A few highlights of the findings are as follows:

- carpoolers tended to come from households with the largest number of workers and the fewest vehicles per worker;
- males tended to use transit more than females;

- small flexibility in work hours promoted carpooling, while large flexibility discouraged it;
- free parking was a strong disincentive to transit use and carpooling; and
- bus pass discounts, transportation coordinators and reserved parking for carpools and vanpools were strong incentives for ridesharing.

COMSIS found that nested logit models did not perform significantly better than a basic logit model.

Logit Modeling for this Project

Two of the objectives of this study were (1) to determine whether a logit model could be calibrated on the data from the employer-based survey in north King and south Snohomish Counties and (2) to compare the results with the COMSIS work that was based on responses from workers in the Bellevue CBD and I-90 corridor.

The responses from 9,534 employees in the corridor were converted from a SAS file to an ASCII file. This data set was unmanageably large, so the number of variables was reduced considerably to concentrate on factors thought to be related to mode choice. At the same time, some of the variables were recoded or reduced to save space. Additionally, skims from 1990 model runs were obtained from the Puget Sound Council of Governments, and data concerning travel times and costs were added appropriately to each record. The result was a manageable data file containing the following variables:

Trip Characteristics

- **mode choice** — mode choices were simplified into six categories, corresponding to the work conducted by COMSIS (SOV, HOV2, HOV3, HOV4+, WALK/BUS and DRIVE/BUS)
- **SOV travel time** — the average travel time between home and work during the peak hour
- **HOV travel time savings** — the difference between SOV and carpool travel time, indicating savings due to use of the HOV lanes on I-5 and SR99
- **walk access to bus** — time to walk from home to the nearest bus stop
- **drive access to bus** — time to drive from home to the nearest bus stop

Individual Characteristics

- **gender** — an indicator variable for male
- **age** — converted to two indicator variables, one for over 45 and one for under 25
- **occupation** — eleven occupational categories were converted to one indicator variable with a value of one for professionals

Household Characteristics

- **income** — converted to two indicator variables, one for household income over $50,000 per year and one for household income under $30,000 per year
- **number of workers** — the total number of employed household members
- **number of vehicles** — the total number of vehicles in the household
- **car availability** — an indicator variable, with one meaning a vehicle was available to the respondent for work trips on a regular basis
- **number of household members over 16 years of age**
- **need car to or from work** — an indicator variable with a value of one if the respondent needed to use a car for errands before or after work at least three times a week

Employer Site Characteristics

- **hours fixed by employer** — an indicator variable with a value of one if the employee had no flexibility in working hours
- **flexible hours** — an indicator variable with a value of one if the employer could choose which hours to work, but maintained a regular schedule
- **variable hours** — an indicator variable with a value of one if work hours varied from day to day
- **need car at work** — an indicator variable with a value of one if the respondent needed to use a car during work at least three times a week
- **bus pass discount** — an indicator variable with a value of one if the employee indicated awareness of a bus pass discount at his/her place of work
- **free parking** — an indicator variable with a value of one if the employee indicated awareness of free parking at his/her place of work

Employer Site Characteristics (Continued)

- **carpool discount** — an indicator variable with a value of one if the employee indicated awareness of a carpool discount at his/her place of work
- **reserved carpool parking area** — an indicator variable with a value of one if the employee indicated awareness of a reserved carpool parking area at his/her place of work
- **vanpool fare discount** — an indicator variable with a value of one if the employee indicated awareness of a vanpool fare discount at his/her place of work
- **guaranteed ride home program** — an indicator variable with a value of one if the employee indicated awareness of a guaranteed ride home program at his/her place of work
- **information center** — an indicator variable with a value of one if the employee indicated awareness of an information center at his/her place of work
- **transportation coordinator** — an indicator variable with a value of one if the employee indicated awareness of a transportation coordinator at his/her place of work

Note that variables concerning employer-based policies appearing at the end of the list of employer site characteristics represented awareness of the programs. It was quite evident that some employees were unaware of programs offered by employers while others indicated that employers offered programs that did not exist.

Calibration of Logit Modeling

Tables 8 to 10 show the results from the logit analysis. Each analysis used the same basic approach. All variables were included in the first specification of the model. Variables that did not contribute significantly ($p < .1$) to the explanation were eliminated one by one until only statistically significant variables remained. A cross-correlation matrix for all variables was created. If a variable remaining in the model correlated greater than 0.2 with some other variable, both were introduced independently into the model. The variable that gave the best results was retained. The tables show only the final results.

Table 8.

Predictors of Mode Choice from Logit Analysis
Three Major Mode Choices

	SOV	POOL	BUS
Trip characteristics:			
SOV travel time	- - -	+++	+
HOV travel time saving	- - -	+++	- - -
Individual characteristics:			
Gender	- -	+++	
Age < 25	- -	++	
Age > 45	- -	+++	
Household characteristics:			
# of workers	- - -	+++	
Income > $50K	- - -	+++	
Need car to/from work	+++	- - -	
Car available	+++	- - -	- - -
Employer site characteristics:			
Variable hours	++	- -	
Free parking	+++	- - -	- - -
Information center	++	- -	
Vanpool fare discount		- -	++
Need car at work	+++	- - -	

Positively related:

+++ p<.01
++ p<.05
+ p<.1

Negatively related:

- p<.1
- - p<.05
- - - p<.01

Table 9.

Predictors of Mode Choice from Logit Analysis
Choice among Carpool Modes

	HOV2	HOV3	HOV4+
Trip characteristics:			
SOV travel time	- - -	+++	+++
Individual characteristics:			
Age < 25		++	
Employer site characteristics:			
Vanpool fare discount		++	
Need car at work	+++		-

Positively related:		Negatively related:	
+++	p<.01	-	p<.1
++	p<.05	- -	p<.05
+	p<.1	- - -	p<.01

Table 10.

Predictors of Mode Choice from Logit Analysis
Choice of SOV over HOV2

	SOV
Trip characteristics:	
HOV cost advantage	- - -
Household characteristics:	
# of workers	- - -
Income > $50K	- - -
Need car to/from work	+++
Car available	+++
Employer site characteristics:	
Variable hours	+++
Free parking	+++
Information center	+++
Need car at work	+++

Positively related:		Negatively related:	
+++	p<.01	-	p<.1
++	p<.05	- -	p<.05
+	p<.1	- - -	p<.01

Table 8 shows the results when the three major mode choices were the alternatives. To see whether a logit model could distinguish among different sizes of carpools, a second analysis was run of carpools only (POOL category from the first analysis). Table 9 shows the results from that analysis. Because the characteristics of HOV2 commuters appeared to be more similar to SOV commuters than HOV3 or HOV4+ commuters, a separate analysis to distinguish SOV and HOV2 commuters was conducted. The results are shown in Table 10. An interpretation of the results of the three analyses follows.

Three Major Mode Choices. Two aspects of the trip influenced mode choice. People were more likely to take the bus or carpool than drive alone if their commute was long. This is similar to findings from most other studies. Secondly, HOV travel time savings was positively related to the likelihood of carpooling. People showed a significant tendency to choose carpooling over driving alone if HOV lanes were between their home and place of work. However, there was a puzzling negative relationship between the existence of HOV lanes and the tendency to take the bus. This may have been due to the characteristics of bus service in the north King and south Snohomish county area. Buses that use the HOV lanes on I-5 do not serve destinations in that area very well. In fact, the people most likely to use the bus probably travel on north-south arterials, not on I-5.

In this group of respondents, males were more likely than females to carpool. Workers under the age of 25 and over 45 were more likely to carpool than workers between those two ages. For the younger workers, this tendency was probably due to less access to an automobile. For older workers, having a working spouse may have been the explanation.

Among the findings for household characteristics there was one surprise. People from households with high income were more likely to carpool than those from households with low income. This unusual finding was difficult to explain. However, it may have had to do with the fact that two worker households have higher household incomes and more opportunity to share rides. This was supported by the fact that a larger number of workers per household related positively to carpooling. Since most carpools are household based, the availability of a convenient carpool partner is a strong influence to share a ride. People who need a car for purposes to and from work are more likely to drive alone than carpool or ride transit. Access to a vehicle has an obvious positive relationship with driving alone.

Needing a car at work also influenced people to drive alone at the expense of carpooling, as did variable hours. Other employer-based policies had relationships with mode choice that were difficult to explain. Three significant employer-based policies influenced mode choice in this analysis: (1) free parking, (2) availability of an information center and (3) provision of a vanpool fare discount. Free parking appeared to encourage driving alone. Availability of an information center also appeared to encourage driving alone. Provision of a vanpool fare discount apparently discouraged pooling (including vanpooling) and encouraged bus riding, according to this analysis.

The relationship between free parking and driving alone was not surprising. However, it must be recalled that the questionnaire asked about awareness of these employer-based polices and **no employer in the sample required employees to pay for parking**. Virtually all the employees in the sample parked in parking lots owned by the employer.

What did it mean that only 30 percent of the respondents replied that they were aware that their employer provided free parking and that those 30 percent were also more likely to drive alone than the other 70 percent? The 70 percent of the respondents who did not indicate that their employer provided free parking may not have perceived parking in an employer-owned lot as "free parking." They may have thought that the employer provided it free only when there was a charge and the employer paid it. The fact that people who were aware that they had free parking were more likely to drive alone to work may have had to do with their tendency to view the free parking as a part of their benefit package, and their desire to take advantage of that benefit. This analysis cannot be used to infer a causal relationship between the **actual** provision of free parking and mode choice, but it does highlight the sensitivity of people's perception of provision of free parking to their travel decisions.

Choice Among Carpool Modes. The fact that the number of workers in the household and household income were both positively related to the tendency to carpool points out the importance of home-based carpools. The fact that home-based carpools were more likely to be composed of two persons and larger carpools were more likely to include members from the workplace leads to the hypothesis that people in two-person carpools differ from larger carpools and vanpools. This hypothesis was tested using a logit analysis of poolers only, distinguishing among different sizes of carpools.

Table 9 shows the results of that analysis. Very few variables entered into the model significantly. Because 27 variables were used in the initial analysis, the fact that only four were significantly related to choice among different sizes of carpools leads to some question about their importance. It is possible that the significant relationships were the result of chance.

The influence of travel time was not unusual. The longer the trip, the more reasonable it is to spend the time necessary to form carpools of three or more people. Hence, two-person carpools tend to be used by people with short trips and larger carpools and vanpools are used by people with longer trips. If someone needs a car at work, it is better to be in small carpool than in a large one, because the likelihood of being able to use the car is greater. The positive relationship between needing a car at work and being in a two-person carpool supported this contention. However, the fact that people under 25 were more likely to be in three-person carpools and that awareness of vanpool fare discounts was also related to participation in a three-person carpool were both difficult to explain, other than that the relationships occurred by chance.

Choice Between Driving Alone and Two-Person Carpool. The fact that carpools and vanpools with more than three people tended to include people who were not from the same household makes it possible that two-person carpools are unique types of ridesharing arrangements. The findings in the previous section supported this contention but did not make a strong case for it. As a further test of this hypothesis, a logit model was used to distinguish between people who drove alone and those who commuted in two-person carpools. All other mode choices were left out of the analysis. Table 10 shows the results of this analysis.

The pattern of relationships in this analysis was very similar to that in Table 8, which contrasted choice among the three major commute modes. This was partly due to the fact that there were many more two-person carpools than larger ones, so the "POOL" category was dominated by that mode. On the other hand, it seems likely, from this analysis, that two-person carpools formed for many of the same reasons that larger carpools formed, with the exceptions that larger ones tended to travel further and provided less flexibility than smaller ones.

Comparison of Results with COMSIS Work. The analysis conducted for this work differed from the COMSIS analysis in some ways that may have affected the comparative results.

- The populations differed. While both study areas were primarily suburban, the COMSIS sample included companies from downtown Bellevue, which is rapidly losing suburban characteristics.
- The variables differed in the two studies. Different information was available in each of the studies.
- The analysis approach was slightly different in the two studies. The COMSIS analysis assessed trade-offs among all six modes at once. This analysis focused on specific comparisons. (A six-mode analysis was conducted for this study, but it revealed no insights that were not apparent in the results reported here.)

Many findings were similar in the two studies. However, there were some substantial differences.

- The number of vehicles per person was not related to mode choice in this study.

- In this study, higher income people were **more** likely to carpool, in contrast to the COMSIS analysis, in which they were less likely to carpool.

- Except for free parking, workplace incentives had less clear relationships with mode choice in this study than in the COMSIS study. Bus pass discounts and reserved parking did not enter significantly into any of the models. The lack of clear relationships may have been due to the fact that they were less salient among the employers in this study's sample than in the COMSIS study's sample.

EXPLORATION OF OTHER MODELING APPROACHES

In addition to the multinomial logit modelling approach used with the employer-based data, other statistical procedures were explored with the telephone survey data to investigate the important factors in model choice. One approach explored the potential for reducing the number of variables needed to explain mode choice through factor analysis. This procedure examines variables for underlying commonalties and groups them into a relatively small number of factors that can provide insight into the basic structure behind the responses. For example, variables that describe the size of the household, the number of household members per worker, or the number of youths in a household may all be combined into one factor called "family size."

In addition, a second procedure used in this study, cluster analysis, is designed to combine respondents into groups that are "like-minded" and respond similarly to a given set of conditions. If one determines from a cluster analysis, for example, that what characterizes a group of commuters is that they (1) have a strong aversion to feeling out of control and (2) do not tend to ride the bus, one could conclude that these two factors are strongly related.

The initial strategy attempted for this analysis was to

1. select an initial set of the most important determinants of mode choice,
2. simplify the variable descriptions through factor analysis,
3. group individual commuters into clusters with common traits,

4. using analysis of variance (ANOVA), check for differences among the clusters for other variables (because the SPSS cluster analysis procedure can handle only a limited number of variables), and

5. repeat the cluster analysis when other important variables were identified through ANOVA.

Using this process, the research team could identify the variables in the data set that were most important for understanding mode choice. The analysis was performed iteratively until only the most important variables were included. As will be seen below, the second step (employing factor analysis) did not contribute successfully to predicting mode choice, but it did provide a possible means for simplifying the variables used in an explanatory model.

Initial Selection of Primary Independent Variables

As discussed earlier, transportation researchers have identified a set of important factors that influence mode choice. To the extent that the available data measured these factors, they were used to provide a starting point for the factor and cluster analysis. For clarity, the variable name used for each variable is included in the narrative and used in the tables. It is placed in parentheses following the variable's description.

Trip Characteristics. Perceived commute times were used both in bus commute (BUSTIME) and car commute times (COMTIME). Research has shown that perceived commute times are a stronger factor in mode choice than actual commute times. Because of the relative importance of parking cost to other travel costs in the mode choice process and the high correlation between travel time and other travel costs, the only travel cost included in the analysis was parking costs (PKG$MO).

Home-end Characteristics. Car availability was measured by the ratio of cars per worker (CARSPWKR). Family characteristics were represented by household members per worker (HMEMPWKR) and youths per worker (YTHPWKR) ratios. The existence of a working spouse (WKGSPOUS) also was included. The type of dwelling of a household (HOMETYPE) was also an initial variable. It was recoded as an indicator variable for a single-family dwelling (SINGLFAM). Some of these variables, of course, were correlated; but each represented different aspects of household characteristics and was therefore included in the initial analysis.

Employment Site Characteristics. Unfortunately, little information on employer policies concerning commuting was available in the telephone survey data. However, errand need (ERRANDS), schedule flexibility (DLYSCHED), number of shopping and other personal trips (PRSWKLY), and arrangements for emergencies (BACKUPCR) are related to commuting to the work site and were included. McCutcheon (1989) identified these as significant correlates of mode choice.

Psychological Aspects. Decision-making styles were not directly measured in the data. However, some aspects of an individual's decision-making process were indirectly measured through attitudes related to the process. They were (1) the level of discomfort around strangers (UNKNWNB), (2) the degree of dislike toward waiting for others (NOWAIT) and, (3) the level of discomfort with feeling inexperienced while learning something new (INEXPER).

Factor Analysis

As mentioned earlier, factor analysis searches for commonalties among variables and groups highly correlated variables into factors. In this way, a large number of variables can be grouped into a more focused number of factors that can more concisely describe major influences on the dependent variable, mode choice.

The following is a detailed description of the process used in the factor analysis.

Correlation Between Variables and Variable Groupings. The initial list of variables derived from the research literature was used in the factor analysis conducted for this study. The procedure analyzed the pattern of correlation among these variables as a basis for factor extraction. This factor extraction phase of the analysis measured the **communality**, or the proportion of variance explained by each factor. If a factor explained no more than the variance explained by a single variable, its communality or **eigenvalue** was equal to one. The greater the eigenvalue, the greater the percentage of total variance that was explained by that factor. Figure 4 provides a graphical display of eigenvalues, called a **scree plot**. As can be seen in Figure 4, after the first four selected factors, the slope of the eigenvalues changes markedly. This indicates a major change in the degree to which each of the subsequent factors explained the total variance. Because of this grouping, the first four factors were selected for the next phase of the analysis. They described 45.2 percent of all variance accounted for by the entire set of selected variables.

Rotation. Once the factors had been selected, they were established as axes in a multidimensional space within which each variable's communality was graphed. These axes were mathematically rotated until the greatest number of variables had the least distance to an axis. The resulting table became the rotated factor matrix described in Table 11. In this table, each factor has a group of variables that are highly correlated with each other. Correlation values of greater than .5000 in absolute value were considered strong enough to remain in the analysis and were listed in Table 11, and conversely, variables with correlations less than .5000 in absolute value were disregarded.

The Four Factors and Their Associated Variables. The initially selected variables are listed on the left-hand column of Table 11. The degrees of correlation for each variable with each factor are in the columns under each factor.

The grouping of the variables describes four factors. In order of importance, they were (1) family composition, (2) perceived car need and ease of use, (3) perceived commute time, and (4) a "control" factor, i.e. the degree of control over daily affairs considered desirable by the respondents.

The first factor was called "Family Composition." The ratio of household members per worker (HMEMPWKR) and youths per worker (YTHPWKR) were the most strongly correlated variables with this factor. (A youth was defined as someone between five and 15 years of age.) Negatively correlated with this factor was whether a working spouse was in the household (WKGSPOUS). The number of cars per worker

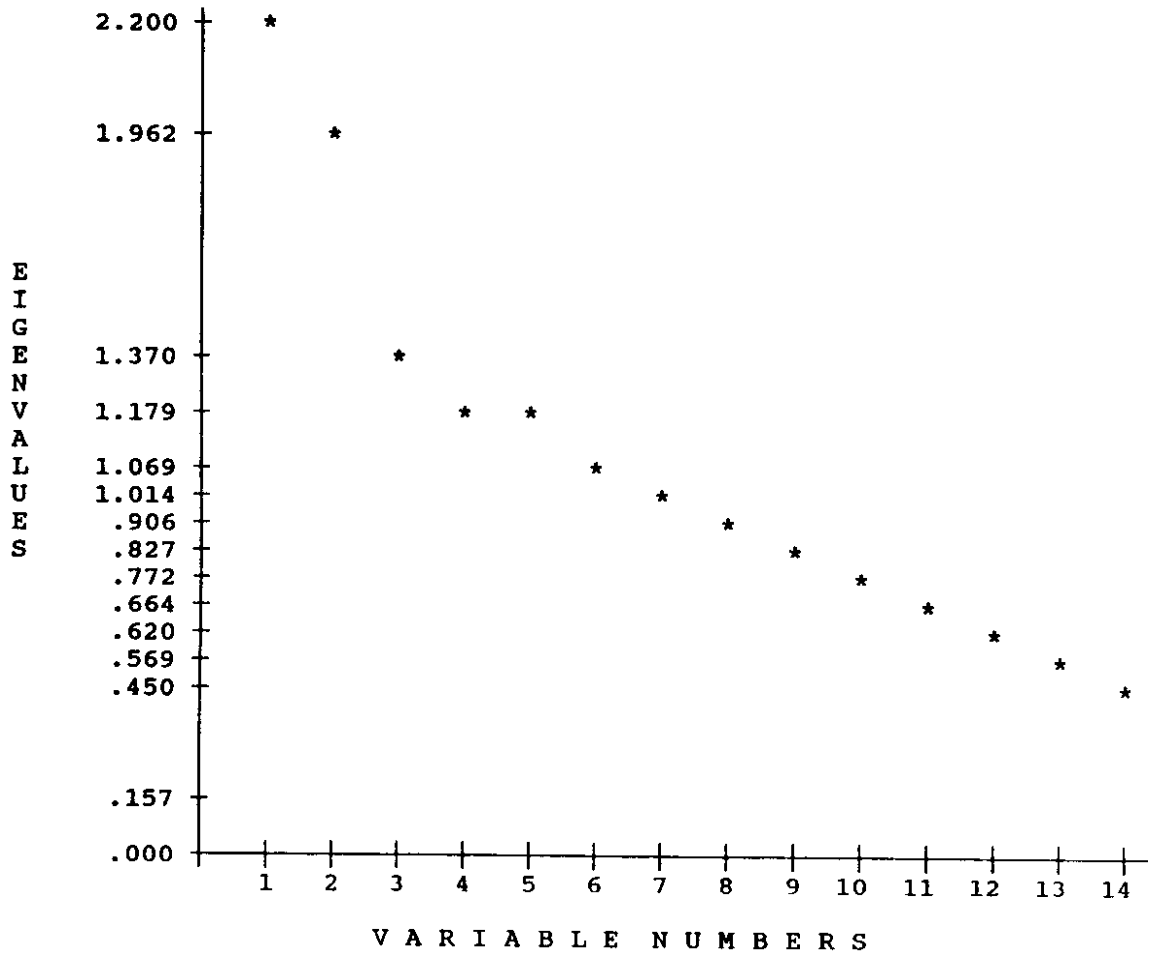

Figure 4.

Scree Plot of Eigenvalues for Selected Variables

Table 11.

Rotated Factor Matrix for Four Factors

	Family Characteristics	Car Need and Ease of Use	Commute Time	"Control"
	Factor 1	Factor 2	Factor 3	Factor 4
HMEMPWKR	.92915			
YTHPWKR	.80353			
WKGSPOUS	-.59479			
CARSPWKR	.40645			
SINGLFAM	.29108			
ERRANDS		.71319		
NEEDCAR		.68368		
PKG$MO		-.63528		
PRSWKLY		.43410		
BUSTIME			.86419	
COMTIME			.71304	
INEXPER				.70260
UNKNWNB				.65503
DLYSCHED				.30652
BACKUPCR				-.18206

Table 12.

Analysis of Variance: Factor by Typical Commute Mode

Factor	Differentiation Between Modes (Scheffe Test)	F Ratio	F Probability
Family Characteristics	none	0.2800	0.8399
Car Need/Ease	1-2,1-3,2-3,2-4*	113.7196	0.0000
Commute Time	none	3.6437	0.0127
"Control"	none	2.1427	0.0922

* 1 = SOV, 2 = Bus, 3 = Pool, 4 = Other

(CARSPWKR) and whether the household was a single family dwelling (SINGLFAM) were positively, but weakly, correlated with this factor. A positive score on the factor indicated the degree to which the household was the so-called "traditional" family, with one worker and several children at home with a non-working adult.

The second factor was called "Car Need and Ease of Use." Most positively correlated in this factor were the degree of perceived need to run errands while traveling to and from work (ERRANDS), the respondent's estimate of the number of days per week that the car was needed for errands to/from work or during the day (NEEDCAR), and the number of shopping or other personal trips taken per week (PRSWKLY). Negatively correlated was whether the respondent faced parking fees upon arriving at work (PKG$MO).

The third factor was called "Commute Time." Most positively correlated was the time needed to travel from home to work by bus as perceived by the respondents (BUSTIME). Less positively correlated was the time required to travel by car from home to work (COMTIME). Differences between these two correlations was probably related to the fact that home sites have differing access to transit.

The fourth factor was called "Need for Control." A high degree of discomfort with inexperience when learning something new (INEXPER) was most positively correlated with this factor. A high degree of discomfort with strangers (UNKNWNB) was also positively correlated, but to a lesser degree.

Comparing Factors with Actual Mode Chosen. An ANOVA procedure was conducted to detect differences among these four factors according to the four groupings of mode choice used in this analysis: SOV, bus, car/vanpool, and other modes. The procedure yielded the information in Table 12, which shows F ratios and an indicator of the statistical probability that the factors differentiated commute modes (the number is the probability that the differences resulted from random variation, rather than actual effects).

Factor 1 (Family Composition) was not significantly related to mode choice. This was surprising, since one would expect that large families with only one worker would have quite different commute needs than other types of households. Factor 2 (Car Need and Ease of Use) varied strongly among modes. This result highlights the importance of parking costs and the perceived need for a car to run errands in modifying mode choice behavior.

Interpretation of the Factor Analysis. Factor analysis provides an idea of the variables that belong together to form major factor groups, and provides a basis for understanding the underlying structure of commuter mode choice. Among the initial variables then, family composition, the perceived need of the car and the ease with which it can be used, commute time, and some measurement of the degree of control desired in one's life, described the major factors. Factor analysis does not identify ways in which individual commuters can be grouped by mode according to these selected variables. The next step of the analysis, called cluster analysis, was conducted to provide further insight.

Cluster Analysis

Cluster analysis searches for commonalties among individual respondents. If two people have similar behavior, values, and decision-making patterns, they will likely answer a questionnaire similarly and will be in the same cluster or group. For this analysis, the initial list of variables described above was used again, this time for the cluster analysis. The analysis assumes these variables are indicators of mode choice behavior, and that a cluster analysis using these variables would be useful to group individuals by mode choice.

The cluster analysis proceeded iteratively. The first clustering used the initial selection of primary independent variables described above. Using analysis of variance, variables were added and subtracted from the list used in the cluster analysis. They were taken off the list if they were not significantly different among the clusters or added to the list if they were thought to add explanatory power and were not directly related to mode choice.

The cluster analysis was accomplished with two SPSS procedures, CLUSTER and QUICK CLUSTER. CLUSTER used a sample of respondents to identify cluster centers. The number of cases CLUSTER can handle depends on the number of variables. The cluster centers identified with CLUSTER were used as initial cluster centers for QUICK CLUSTER. The latter statistical package can handle a larger number of cases. Using that procedure, all cases for which there were data could be assigned to a cluster.

Final Grouping. The cluster analysis used 511 responses, all of those that had included data responses for all of the variables, a requirement of the cluster analysis. After the cases were grouped into four clusters (see Table 13), cross-tabulations of cluster membership and mode choice revealed three major clusters:

1. a group predominantly of bus riders, called in this report Cluster 1 or the "Bus-oriented Cluster;"

2. another of commuters who had a lower tendency to take the bus than other clusters, called Cluster 4, or the "Auto-oriented Cluster;" and

3. the largest cluster, a blended cluster of bus, pool and SOV commuters whose family composition and commute distance predominantly differentiated it from other groups, called Cluster 3 or the "Traditional Commuter Cluster."

Table 13.

Cross-tabulation of Cluster Grouping by Typical Mode Taken

Typical Mode	Bus-oriented Cluster 1	Non-driver Cluster 2	Traditional Commuter Cluster 3	Auto-oriented Cluster 4	Row Total
SOV	4	0	117	142	263 51.5
Bus	41	13	60	19	133 26.0
Pool	3	5	40	43	91 17.8
Other	1	0	14	9	24 4.7
Column Total	49 9.6	18 3.5	231 45.2	213 41.7	511 100.0

A fourth, small group of commuters had no driver's licenses and were grouped together in Cluster 2, the "Non-driver Cluster." This group will be discussed in a later section of this paper.

It is interesting to note how non-SOV modes were distributed among the three major clusters. One cluster clearly was composed primarily of bus riders. However, a sizable number of bus riders were in the Traditional Commuter Cluster (and, to a lesser extent, are found in the so-called Auto-oriented Cluster). The following analysis examines the differences among bus riders in the different groups.

In contrast with bus riders, no cluster was clearly composed of carpoolers and vanpoolers. However, they were fairly evenly split between the Traditional Commuter and SOV Clusters. Again, the following analysis will examine the differences between the poolers in these two clusters.

Analysis of All Other Variables. Once the clusters had been established, t-tests were conducted on the original variables used for the clustering and all other continuous variables in the Metro telephone survey. This procedure was done to identify further variables that could distinguish among the clusters and to determine why people with similar mode choices were included in different clusters. Table 14 is a tabular representation of the differing means and associated t-test probabilities for each variable.

Three comparisons were made:

- SOV commuters split relatively evenly between the Traditional Commuter Cluster and the Auto-oriented Cluster; therefore, these two groups were compared.
- Pool commuters also split relatively evenly between the same two clusters, and were analyzed similarly.
- Bus commuters split between the Bus-oriented Cluster and the Traditional Commuter Cluster, and the two groups were compared.

Figure 5 provides graphically the results of these analyses. The predominant characteristics for all modes of the Traditional Commuter Cluster (Cluster 3) are summarized in the center of the diagram. Within each of the sectors of the Traditional

Table 14.

Comparing Means and t-test Probabilities between Selected Mode Clusters

X INDICATES MEAN IS LARGER FOR THAT VARIABLE

DESCRIPTION	VARIABLE NAME	SOV3 CLUSTER 3	SOV4 CLUSTER 4	SOV T-TEST PROB	BUS3 CLUSTER 3	BUS1 CLUSTER 1	BUS T-TEST PROB	POOL3 CLUSTER 3	POOL4 CLUSTER 4	POOL T-TEST PROB
EST. CAR COMMUTE TIME	COMTIME	X		0.010	X		0.006			
EST. BUS COMMUTE TIME	BUSTIME	X		0.001	X		0.034	X		0.039
HOUSEHOLD CHARACTERISTICS:										
NO. OF CARS IN HOUSEHOLD/WORKER	CARSPWKR				X		0.012			
HOUSEHOLD MEMBERS/WORKER	HMEMPWKR	X		0.011				X		0.017
YOUTH/WORKER	YTHPWKR	X		0.012				X		0.040
NO. HOUSEHOLD 5 TO 15 YEARS OLD	FIVFIFT	X		0.011				X		0.047
NUMBER OF STUDENTS OVER 16 YRS	SCHOOL	X		0.042						
COMMUTER HAS WORKING SPOUSE	WKGSPOUS								X	0.042
EDUCATION LEVEL OF COMMUTER	EDUCLEVL	X		0.032						
EXISTING CONDITIONS:										
DEGREE OF DAILY SCHEDULE FLEXIBILITY	DLYSCHED					X	0.034			
HAS PARKING COSTS	PKGSMO					X	0.017			
PRESENTLY USE HOV LANES TO COMMUTE	HOVLANE							X		0.028
NO. RIDES/WEEK ON LOCAL BUS	LOCBUS					X	0.042			
DISTANCE TO NEAREST BUSSTOP	BUSDIST				X		0.001			
CT/METRO SERVICE USED TO UNIV OF WA	TRANSV4					X	0.000			
HHLD MEMBERS USE METRO TRANSIT CENTER	MTSV8							X		0.038
BUS PASS SUBSIDY FROM EMPLOYER	BUSPASS	X		0.026		X	0.000			
VANPOOL PASS SUBSIDY FROM EMPLOYER	POOLPASS	X		0.051				X		0.037
SPECIAL PARKING FOR POOL FROM EMPLOYER	POOLPARK	X		0.020						
ATTITUDES ON CONTROL:										
NOT COMFORTABLE WITH STRANGERS	UNKNWNB		X	0.000		X	0.034		X	0.000
DISLIKE FEELING INEXPERIENCED	INEXPER		X	0.010					X	0.028
COMMUTING GIVES TIME TO SELF	ALONETIM		X	0.000						
DISLIKE WAITING FOR OTHERS	NOWAIT		X	0.000						
ATTITUDES ON HOV LANES:										
HOV LANE NOT FAIR	NOHOVLN		X	0.000					X	0.018
HOV LANE GOOD, FAST, ECONOMICAL	POOLFAST		X	0.000					X	0.026

Table 14. (Continued)

Comparing Means and t-test Probabilities between Selected Mode Clusters

DESCRIPTION	VARIABLE NAME	SOV CLUSTER 3	SOV CLUSTER 4	SOV T-TEST PROB	BUS CLUSTER 3	BUS CLUSTER 1	BUS T-TEST PROB	POOL CLUSTER 3	POOL CLUSTER 4	POOL T-TEST PROB
ATTITUDES ON CAR USE:										
IF CHOICE, ALWAYS USE CAR	ALWYSCAR	X		0.000				X		0.002
IF GAS PRICE REMAINS LOW, WILL USE CAR	GAS$	X		0.000				X		0.000
OFTEN RUN ERRANDS WHILE TO/FROM WORK	ERRANDS					X	0.050			
ATTITUDES ON BUS USE:										
DISLIKE WALK TO BUSSTOP	NOWALKB	X		0.000				X		0.002
UNWILLING TO BUS TRANSFER	NOTRANSB	X		0.000				X		0.001
ENJOY READ/RELAX WITH COMMUTE	RELAXB		X	0.000					X	0.003
WORRY ABOUT DISTURBANCES ON BUS	BDISTURB		X	0.000						
BEST THING, NO PARK PROB IN CBD W/BUS	NOPKGB	X		0.021						
DONT MIND PACKAGES ON BUS	PAKBUS							X		0.004
WILLINGNESS TO USE NEW SERVICES:										
WOULD USE EMPLOYER-PROVIDED BACKUPCAR	BACKUPCR	X		0.000				X		0.023
WOULD USE CONVENIENT RAIL	USERAIL		X	0.000		X	0.019		X	0.003
IF CONVENIENT WOULD BUS (SOV ONLY)	LIKLBUS	X		0.000						
IF CONVENIENT WOULD POOL (SOV ONLY)	LIKLPOOL	X		0.002						
IF " WLD USE PR LOTS (SOV ONLY)	LIKLPR	X		0.002						
WOULD USE SUBURB TO SUBURB TRANSIT	SUBCOMM	X		0.000						
IF HOV LANE ACCESS, WOULD USE MORE BUS	MOREBUS		X	0.006						
IF HOV LANE, WOULD USE MORE CPOOL	MORECPL		X	0.004						
IF HOV LANE, WOULD USE MORE VPOOL	MOREVPL		X	0.000						
WOULD USE TRANSIT CENTERS IF AVAILABLE	TRANCTRS		X	0.000						
WOULD LIKE CASH MACHINE FOR BUS PASS	CASHMACH	X		0.024						
WOULD USE SHUTTLE IN NBRHOOD FOR STORES	SHUTTLE	X		0.008						
WOULD USE ADD'TL SERVICES AT PR LOTS	PRSERV	X		0.002						
WOULD USE COMBO PR LOTS AND TRAIN	PRTRAIN	X		0.000						
WOULD USE SPECIAL RESERVED BUS	SPECBUS	X		0.000				X		0.051
WOULD USE NEW BUS ROUTE	NEWBUS		X	0.004					X	0.037

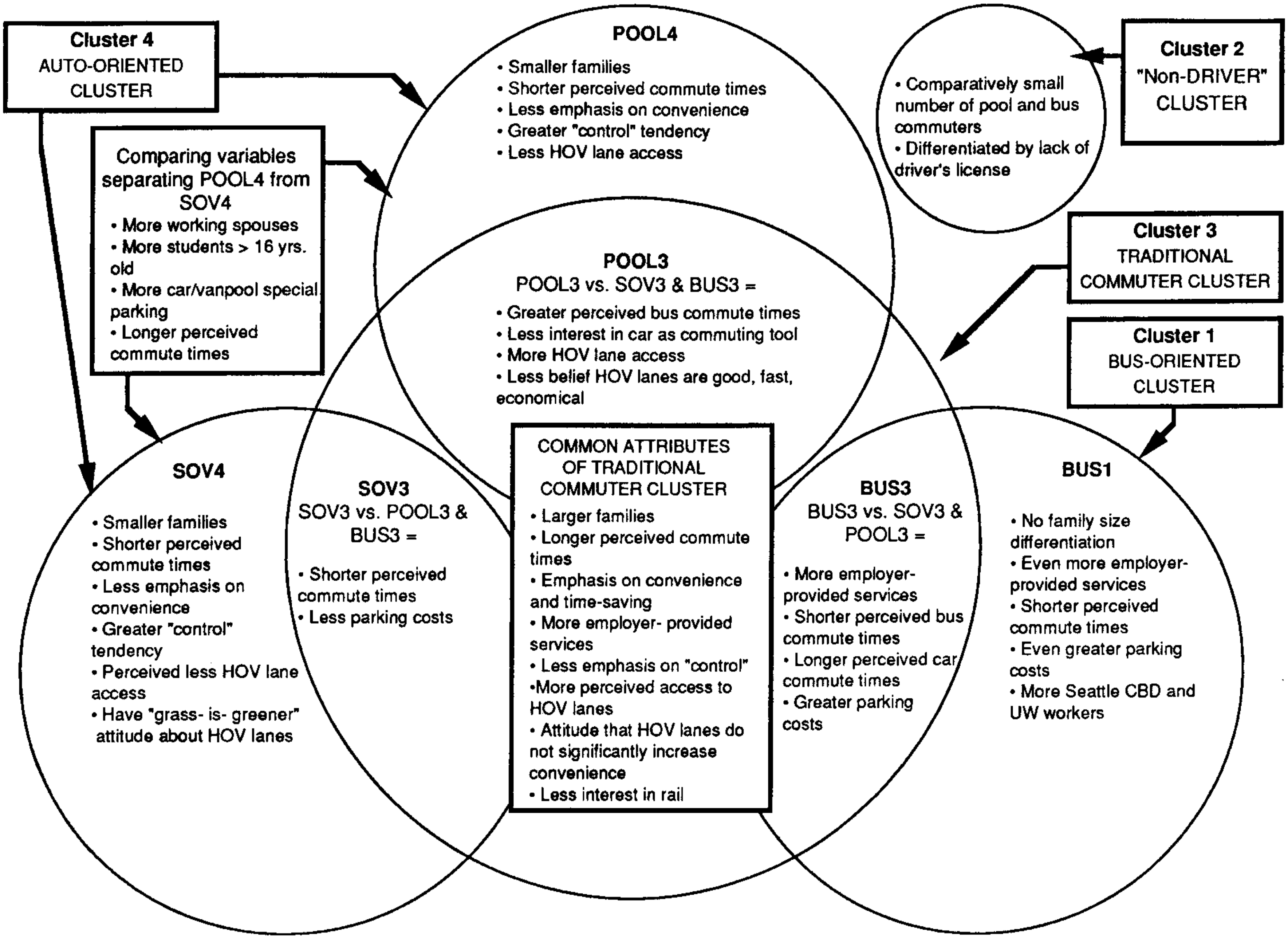

Figure 5. Diagram of Mode Clusters and Their Characteristics

Commuter Cluster, labeled SOV3, POOL3 and BUS3, are the characteristics that differentiate the modes within the Traditional Commuter Cluster. The other two predominant groups resulting from the analysis, the Bus-oriented Cluster (Cluster 1, called BUS1), and the Auto-oriented Cluster (Cluster 4, called BUS4), are both outside of the Traditional Commuter Cluster circle. The Auto-oriented Cluster is broken graphically into two parts, labeled SOV4 and POOL4, to assist visually with the creation of separate circles for each of the modes: SOV, Bus, and Pool. The figure illustrates the following observations:

- Characteristics of the Traditional Commuter Cluster. SOV, pool, and bus commuters in the Traditional Commuter Cluster shared the characteristics of (1) larger families, (2) longer commutes, (3) an emphasis on convenience and time-saving, (4) more employer-provided transportation services available to them, and (5) less interest in "control" in their daily lives.

- Larger families in the Traditional Commuter Cluster. The "Household Characteristics" section of Table 14 shows that both SOV and pool commuters in the Traditional Commuter Cluster had higher household members per worker and youths per worker ratios than those outside of the Traditional Commuter Cluster. However, this did not differentiate the two bus commuter groups, one inside and the other outside of the Traditional Commuter Cluster.

- Family size for bus commuters in the Traditional Commuter Cluster. A comparison of all cases in the Traditional Commuter Cluster with bus commuters in the cluster (see Table 15) revealed that the difference in number of household members per worker was not statistically significant. However, the youths per worker ratio was significantly less for the bus commuters in the Traditional Commuter Cluster.

- Longer commute times in the Traditional Commuter Cluster. A comparison of Table 14's perceived commute times for each mode within and outside the Traditional Commuter Cluster shows that all three major modes within the Traditional Commuter Cluster had larger mean perceived commute times.

- Convenience and time-saving in the Traditional Commuter Cluster. The "Attitudes on Car Use" section of Table 14 shows that both the SOV and pool commuters in the Traditional Commuter Cluster shared a stronger tendency to always choose the car if given a choice, or as long as gas prices remained low. However, these same SOV commuters would use the bus, carpool, or park-and-ride lots, if convenient. This result implies a desire by this group to pick the mode that would most quickly and conveniently satisfy their transportation needs.

Table 15.

Comparing Means and t-test Probabilities between Modes within the Traditional Commuter Cluster

X INDICATES MEAN IS LARGER FOR THAT VARIABLE

DESCRIPTION	VARIABLE NAME	SOV3 CLUSTER 3	OTHER CLUSTER 3	SOV3 T-TEST PROB	BUS3 CLUSTER 3	OTHER CLUSTER 3	BUS3 T-TEST PROB	POOL3 CLUSTER 3	OTHER CLUSTER 3	POOL3 T-TEST PROB
EST. CAR COMMUTE TIME	CONTIME		X	0.000	X		0.000			
EST. BUS COMMUTE TIME	BUSTIME					X	0.000	X		0.044
HOUSEHOLD CHARACTERISTICS:										
NO. OF CARS IN HOUSEHOLD/WORKER	CARSPWKR									
HOUSEHOLD MEMBERS/WORKER	HMEMPWKR									
YOUTH/WORKER	YTHPWKR					X	0.001			
NO. HOUSEHOLD 5 TO 15 YEARS OLD	FIVFIFT					X	0.002			
NUMBER OF STUDENTS OVER 16 YRS	SCHOOL									
COMMUTER HAS WORKING SPOUSE	WKGSPOUS									
EDUCATION LEVEL OF COMMUTER	EDUCLEVL									
EXISTING CONDITIONS:										
DEGREE OF DAILY SCHEDULE FLEXIBILITY	DLYSCHED	X		0.025		X	0.021			
HAS PARKING COSTS	PKGSMO		X	0.000	X		0.000			
PRESENTLY USE HOV LANES TO COMMUTE	HOVLANE									
NO. RIDES/WEEK ON LOCAL BUS	LOCBUS									
DISTANCE TO NEAREST BUSSTOP	BUSDIST				X		0.008			
CT/METRO SERVICE USED TO UNIV OF WA	TRANSV4									
HHLD MEMBERS USE METRO TRANSIT CENTER	MTSV8		X	0.000	X		0.001			
BUS PASS SUBSIDY FROM EMPLOYER	BUSPASS				X		0.018			
VANPOOL PASS SUBSIDY FROM EMPLOYER	POOLPASS									
SPECIAL PARKING FOR POOL FROM EMPLOYER	POOLPARK									
ATTITUDES ON CONTROL:										
NOT COMFORTABLE WITH STRANGERS	UNKNWNB									
DISLIKE FEELING INEXPERIENCED	INEXPER									
COMMUTING GIVES TIME TO SELF	ALONETIM					X	0.008	X		0.017
DISLIKE WAITING FOR OTHERS	NOWAIT									
ATTITUDES ON HOV LANES:										
HOV LANE NOT FAIR	NOHOVLN					X	0.033			
HOV LANE GOOD, FAST, ECONOMICAL	POOLFAST				X		0.014		X	0.027

Table 15. (Continued)

Comparing Means and t-test Probabilities between Modes within the Traditional Commuter Cluster

DESCRIPTION	VARIABLE NAME	SOV3 CLUSTER 3	OTHER CLUSTER 3	SOV3 T-TEST PROB	BUS3 CLUSTER 3	OTHER CLUSTER 3	BUS3 T-TEST PROB	POOL3 CLUSTER 3	OTHER CLUSTER 3	POOL3 T-TEST PROB
ATTITUDES ON CAR USE:										
IF CHOICE, ALWAYS USE CAR	ALWYSCAR		X	0.001	X		0.000		X	0.008
IF GAS PRICE REMAINS LOW, WILL USE CAR	GAS$		X	0.000	X		0.000		X	0.051
OFTEN RUN ERRANDS WHILE TO/FROM WORK	ERRANDS		X	0.001	X		0.000			
ATTITUDES ON BUS USE:										
DISLIKE WALK TO BUSSTOP	NOWALKB									
UNWILLING TO BUS TRANSFER	NOTRANSB									
ENJOY READ/RELAX WITH COMMUTE	RELAXB	X		0.001		X	0.000			
WORRY ABOUT DISTURBANCES ON BUS	BDISTURB									
BEST THING, NO PARK PROB IN CBD W/BUS	NOPKGB									
DONT MIND PACKAGES ON BUS	PAKBUS									
WILLINGNESS TO USE NEW SERVICES:										
WOULD USE EMPLOYER-PROVIDED BACKUPCAR	BACKUPCR									
WOULD USE CONVENIENT RAIL	USERAIL									
IF CONVENIENT WOULD BUS (SOV ONLY)	LIKLBUS									
IF CONVENIENT WOULD POOL (SOV ONLY)	LIKLPOOL									
IF " WLD USE PR LOTS (SOV ONLY)	LIKLPR									
WOULD USE SUBURB TO SUBURB TRANSIT	SUBCOMM									
IF HOV LANE ACCESS, WOULD USE MORE BUS	MOREBUS									
IF HOV LANE, WOULD USE MORE CPOOL	MORECPL									
IF HOV LANE, WOULD USE MORE VPOOL	MOREVPL									
WOULD USE TRANSIT CENTERS IF AVAILABLE	TRANCTRS							X		0.019
WOULD LIKE CASH MACHINE FOR BUS PASS	CASHMACH									
WOULD USE SHUTTLE IN NBRHOOD FOR STORES	SHUTTLE									
WOULD USE ADD'TL SERVICES AT PR LOTS	PRSERV									
WOULD USE COMBO PR LOTS AND TRAIN	PRTRAIN									
WOULD USE SPECIAL RESERVED BUS	SPECBUS									
WOULD USE NEW BUS ROUTE	NEWBUS									

- Willingness to use new services in the Traditional Commuter Cluster. SOV commuters in the Traditional Commuter Cluster expressed a stronger interest in new services than did the SOV counterparts outside the Traditional Commuter Cluster. This could also be interpreted as an indication that these SOV commuters were willing to try something new as long as it addressed their underlying need for increased convenience and/or time-saving that would reduce their longer commutes.

- More employer-provided services in the Traditional Commuter Cluster. All three modes in the Traditional Commuter Cluster tended to have more employer-based services than their counterparts in other clusters, such as bus pass subsidies and preferred parking for carpools and vanpools. These were the only employer-provided services that showed statistically significant differences between groups.

- Less "need for control" in the Traditional Commuter Cluster . Both the SOV and pool commuters in the Traditional Commuter Cluster expressed less agreement with variables indicating a desire for "control" over their life than similar commuters outside the cluster. They expressed less discomfort around strangers and less dislike of feeling inexperienced when learning something new. The SOV commuters in the Traditional Commuter Cluster additionally felt less dislike in waiting for others and less interest in time to oneself while commuting than SOV commuters outside the cluster.

- HOV lane convenience to SOV commuters. SOV commuters in the Traditional Commuter Cluster did not perceive that HOV lanes significantly increased convenience. SOV commuters within the Traditional Commuter Cluster responded with a greater tendency than the SOV commuters "outside" the Traditional Commuter Cluster to want to use other modes and HOV facilities if convenient, and a decreased tendency to use other modes and HOV facilities if they had HOV lane access. At first glance, it seems this SOV group contradicted itself. They can be interpreted as saying that they would use almost any mode or facility as long as it increased their commuting convenience; but in their estimation, HOV lanes, at this time at least, do not increase that convenience level.

- HOV lane convenience to pool commuters. Pool commuters in the Traditional Commuter Cluster did not perceive that HOV lanes significantly increase convenience. A similar conclusion could be derived for the POOL3 and POOL4 commuters inside and outside of the Traditional Commuter Cluster. POOL3 commuters exhibited a greater tendency to use HOV lanes than the POOL4 group, but they also responded with a decreased tendency to believe that HOV lanes are good fast and economical. A similar conclusion was therefore derived, that HOV lanes do not significantly enhance the commute times for pool commuters in the Traditional Commuter Cluster at this time.

- The "grass-is-greener" phenomenon. According to the previous discussion, congestion has not quite reached a level sufficient for HOV lanes to be seen as a great advantage by the commuters that use them. On the other hand, HOV lanes do seem like an important advantage to those that do not use them. By far the largest majority of commuters in the study area drove alone; it could be inferred that commute conditions have not yet deteriorated to a level to cause SOV commuters to change their behavior but have deteriorated sufficiently for them to begin to change their attitudes. This "grass-is-greener" attitude by SOV commuters about the advantages of using HOV lanes may be an optimistic sign that conditions are ripe for policy changes that will cause a significant mode shift to HOV modes.

- <u>Less interest in rail within the Traditional Commuter Cluster</u>. All mode clusters "outside" the Traditional Commuter Cluster exhibited a greater willingness to use a convenient rail system. This is consistent with the "grass-is-greener" attitude exhibited by SOV commuters about the advantages of using HOV lanes. However, in this case it extends to both POOL4 and BUS1 commuter groups outside the Traditional Commuter Cluster as well. The mode groups within the Traditional Commuter Cluster seemed consistently cynical about the convenience of HOV lanes under present conditions, and carried that cynicism to the potential advantages of a new rail system for the region.

- <u>Characteristics that separate modes within the Traditional Commuter Cluster</u>. Table 15 identifies the variables that statistically differentiate each mode within the Traditional Commuter Cluster. These variables are listed in Figure 5 within SOV3, BUS3 and POOL3. The main determinants for separating modes within the Traditional Commuter Cluster seemed to be perceived commute times, HOV incentives, and the existence of parking costs.

- <u>Pool commuters within the Traditional Commuter Cluster</u>. Pool commuters in this cluster expressed less interest in the car than bus or SOV commuters and less belief that HOV lanes are good, fast, and economical. However, this group used HOV lanes more than the pool commuters outside of the Traditional Commuter Cluster. This result could indicate that they were not realizing significant time-savings through use of HOV lanes, and therefore did not see them as a significant advantage.

- <u>SOV commuters within the Traditional Commuter Cluster</u>. The SOV commuters had fewer incentives to use HOV facilities in that they had shorter commutes than the rest in the Traditional Commuter Cluster and were less likely to be faced with parking costs. This indicates that they had a greater tendency to work in suburban locations. They were also less likely to feel that they needed the car as a commuting tool, perhaps indicating that they would be willing to change modes if incentives existed. Conversely, this tendency of the other two modes in the Traditional Commuter Cluster to want to use the car as a commuting tool could indicate a degree of frustration toward carpooling and transit use, but acceptance of these modes because of HOV incentives and SOV disincentives. This conclusion is plausible because (1) all modes in the Traditional Commuter Cluster shared an emphasis on convenience and speed and (2) SOV commuters had an average commute time that was shorter than all other modes.

- <u>Bus commuters within the Traditional Commuter Cluster</u>. The bus commuters in the Traditional Commuter Cluster were differentiated from other modes in the cluster by more incentives to rideshare, perceived shorter bus commutes, perceived longer car commutes, and greater parking costs. Despite these tendencies, they still scored higher in preference for a car if given a choice.

- SOV and pool commuters "outside" the Traditional Commuter Cluster. Both of these commuter groups shared many commonalties and were grouped by the cluster analysis procedure into Cluster 4, the Auto-oriented Cluster. The converse of what was true for the Traditional Commuter Cluster applied to them: they had smaller families, generally shorter commutes, less emphasis on convenience, more of a "control" tendency, and less perceived HOV lane access. Table 16 lists the differentiating factors between these two groups. They are additionally summarized within SOV4 and POOL4 in Figure 5.

- Pool commuters in the Auto-oriented Cluster. The POOL4 commuters had a greater tendency to have a working spouse or student over 16 years of age, a longer perceived car commute, and special parking for car and vanpools than the SOV4 commuters. Implied here, as elsewhere in the analysis, is that employer-based services, such as preferred parking for car and vanpools, are effective in changing mode behavior. The POOL4 commuters desired suburb to suburb transit service more than the SOV4 commuters; whereas the SOV4 commuters had a greater willingness to use the bus more if they had HOV lane access.

- Bus commuters outside the Traditional Commuter Cluster. The bus commuters who were "outside" of the Traditional Commuter Cluster are within the Bus-oriented Cluster, or BUS1, in Figure 5. This group differed from the BUS3 commuters in the Traditional Commuter Cluster in that they were more likely to pay parking costs, had a greater likelihood of possessing a bus pass subsidy as an employer-provided service, had more daily schedule flexibility and a shorter perceived commute time. These results reinforce the observation that employer-based services, parking limitations and significant parking costs encourage HOV use.

Summary of Cluster Analysis. Two clusters were composed primarily of bus riders, one because members did not have driver's licenses and the other because of strong incentives to use a bus, such as employer-provided subsidies and high parking charges. Two other clusters contained a mix of modes. The Traditional Commuter Cluster was differentiated from the non-Bus-oriented Cluster because members of the cluster tended to have larger families and only one worker in the household. It also turns out that there was a much higher proportion of bus commuting in the first group than the second (hence, the name for the second).

Table 16.

Comparing Means and t-test Probabilities between SOV and POOL Modes in the Traditional Commuter Cluster

X INDICATES MEAN IS LARGER FOR THAT VARIABLE

DESCRIPTION	VARIABLE NAME	SOV4 CLUSTER 4	POOL4 CLUSTER 4	T-TEST PROB
EST. CAR COMMUTE TIME	COMTIME		X	0.006
EST. BUS COMMUTE TIME	BUSTIME			
HOUSEHOLD CHARACTERISTICS:				
NO. OF CARS IN HOUSEHOLD/WORKER	CARSPWKR			
HOUSEHOLD MEMBERS/WORKER	HMEMPWKR			
YOUTH/WORKER	YTHPWKR			
NO. HOUSEHOLD 5 TO 15 YEARS OLD	FIVFIFT			
NUMBER OF STUDENTS OVER 16 YRS	SCHOOL		X	0.019
COMMUTER HAS WORKING SPOUSE	WKGSPOUS		X	0.047
EDUCATION LEVEL OF COMMUTER	EDUCLEVL			
EXISTING CONDITIONS:				
DEGREE OF DAILY SCHEDULE FLEXIBILITY	DLYSCHED		X	0.011
HAS PARKING COSTS	PKG$MO			
PRESENTLY USE HOV LANES TO COMMUTE	HOVLANE			
NO. RIDES/WEEK ON LOCAL BUS	LOCBUS			
DISTANCE TO NEAREST BUSSTOP	BUSDIST			
CT/METRO SERVICE USED TO UNIV OF WA	TRANSV4			
HHLD MEMBERS USE METRO TRANSIT CENTER	MTSV8			
BUS PASS SUBSIDY FROM EMPLOYER	BUSPASS			
VANPOOL PASS SUBSIDY FROM EMPLOYER	POOLPASS			
SPECIAL PARKING FOR POOL FROM EMPLOYER	POOLPARK		X	0.015
WILLINGNESS TO USE NEW SERVICES:				
WOULD USE EMPLOYER-PROVIDED BACKUPCAR	BACKUPCR			
WOULD USE CONVENIENT RAIL	USERAIL			
IF CONVENIENT WOULD BUS (SOV ONLY)	LIKLBUS			
IF CONVENIENT WOULD POOL (SOV ONLY)	LIKLPOOL			
IF " WLD USE PR LOTS (SOV ONLY)	LIKLPR			
WOULD USE SUBURB TO SUBURB TRANSIT	SUBCOMM		X	0.025
IF HOV LANE ACCESS, WOULD USE MORE BUS	MOREBUS	X		0.023
IF HOV LANE, WOULD USE MORE CPOOL	MORECPL			
IF HOV LANE, WOULD USE MORE VPOOL	MOREVPL			
WOULD USE TRANSIT CENTERS IF AVAILABLE	TRANCTRS			
WOULD LIKE CASH MACHINE FOR BUS PASS	CASHMACH			
WOULD USE SHUTTLE IN NBRHOOD FOR STORES	SHUTTLE			
WOULD USE ADD'TL SERVICES AT PR LOTS	PRSERV			
WOULD USE COMBO PR LOTS AND TRAIN	PRTRAIN			
WOULD USE SPECIAL RESERVED BUS	SPECBUS			
WOULD USE NEW BUS ROUTE	NEWBUS			

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