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Toward Estimating Intelligent Transportation System Benefits Based on User Needs

Final Report

Prepared with sponsorship through the University of Michigan
Intelligent Transportation System Research Center for Excellence

Barbara C. Richardson
Hui-Chun Huang
Brian N. Ebarvia
Owen P. Kearney

December 2000
Report No.: ITSRCE 939424
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16. Abstract

With anticipated demographic and economic changes, there is an expectation of need for innovative transportation for different segments of society, for drivers as well as nondrivers. In this study, two groups, the elderly and those of low income, were studied in regard to their current and future transportation needs and modes. It is anticipated that intelligent transportation system technologies could help meet these needs. A review of the literature was supplemented by interviews with service providers and focus groups. The findings of the study are organized by which intelligent transportation solutions (for both personal and public modes) are likely to contribute positively in meeting the desired transportation attributes indicated by the two populations. It was found that travel and transportation demand management, electronic payment, and public transportation operations will yield the most benefits to the elderly and low-income people in terms of their desired transportation attributes.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS

I. INTRODUCTION, BACKGROUND, AND STATEMENT OF PROBLEM 1

II. APPROACH AND METHODOLOGY 4

III. LITERATURE SEARCH 5

A. Transportation Needs of the Elderly 5
1. Characteristics of the elderly population 5
2. Reported trip purposes 7
3. Difficulties/issues in meeting transportation needs 9
4. Summary 14
B. Transportation Needs of the Low-Income Population 14
1. Profile of the low-income population 15
2. Reported travel characteristics of low-income population 16
3. Emerging transportation needs of the low-income population 23
C. How the Transportation Needs of the Elderly are Being Met 30
1. Personal vehicle/driving solutions 31
2. Nonpersonal vehicle/nondriving solutions 32
D. Solutions to the Transportation Needs of the Low-Income Population 33
1. Non-ITS solutions 34
2. ITS solutions 35

IV. FINDINGS FROM FOCUS GROUPS AND INTERVIEWS 40

A. Background 40
B. Interviews 40
C. Focus Groups 40
1. Method 40
2. Participant description 41
3. Focus group discussion 41
4. Trip purposes 44
5. Transportation attributes 45
D. Summary of Findings from Focus Groups and Interviews 46

V. ANALYSIS 47

A. Trends 47
B. Potential Solutions 48

VI. SUMMARY AND CONCLUSIONS 55

A. Overview 55
B. Observations 55
C. Findings, Conclusions, and Recommendations 56

REFERENCES 58

APPENDICES

A. Poverty Status of Persons by Age, Ethnicity, Region, and Family Type, 1996 68
B. Composition of Poverty Population for Selected Demographic Groups, Selected Years 1959-1996. 68
C. Poverty Rates by Family Type, Selected Years, 1987-1996 69
D. Number of Person Trips by Household Income and Mode of Transportation 1990 NPTS (Millions) 70
E. Number of Person Miles of Travel By Household Income and Mode of Transportation 1990 NPTS (Millions) 71
F. Number of Person Trips and Person Miles By Mode of Transportation for Household Income ≤ $10,000 72
G. Percent of Person Miles of Travel by Trip Purpose by Household Income Groups, 1983 and 1990 73
H. Average Daily Person Trips, Person Travel, and Person Trip Length by Household Income and Trip Purpose, 1990 73
I. Average Daily Person Trips, Person Travel, and Person Trip Length by Trip Purpose for Household Income ≤ $10,000, 1990 74
J. Focus Group Questionnaire 75

LIST OF TABLES

1. Reported Trip Purposes of the Elderly, 1977, 1990, 1995-1997 8
2. Modal Distribution for Urban Travel by Income Class, 1969 17
3. The Composition of Urban Transportation Mode, Riders by Income Class (U.S. Aggregate, All Purposes, 1969) 18
4. Average Vehicle Occupancy for Private Vehicle Trips (weighted by Miles), 1995 19
5. Vehicle Availability by Income Group, 1995 20
6. Impairments, Problems, and ITS Equipment for Older Car Drivers 33
7. Impairments, Problems, and ITS Equipment for Older and Less Able Bus Passengers 34
8. Future Transportation Purposes and Destinations Reported in Focus Groups 42
9. Future Transportation Options and Characteristics Suggested in Focus Groups 44
10. Consensus Ranking of Attributes in Order of Importance 46
11. Personal Transportation Attributes Desired by Low-Income People and Potential ITS Solutions 49
12. Personal Transportation Attributes Desired by Elderly People and Potential ITS Solutions 51
13. Public Transportation Attributes Desired by Low-Income People and Potential ITS Solutions 53
14. Public Transportation Attributes Desired by Elderly People and Potential ITS Solutions 54

LIST OF FIGURES

1. Crash Involvement Per 1,000 Licensed Drivers 12
2. Driver Fatality Rate Per 100 Million VMT, 1994 12
3. Crash Fatality Rates by Population, 1997 13
4. Age/Fragility Relationship Fatalities Per 1000 Crashes, 1983 13
5. Mode Choice of the Poverty Population for Work Trips, 1985 & 1989 16

I. INTRODUCTION, BACKGROUND, AND STATEMENT OF PROBLEM

This report summarizes the effort of a project entitled "Toward Estimating Intelligent Transportation System Benefits Based on User Needs," funded through the University of Michigan Intelligent Transportation System Research Center of Excellence. It was conducted between May 1997 and December 1999. The research team includes project director Barbara Richardson, Ph.D., of the University of Michigan Transportation Research Institute, and University of Michigan students, Hui-Chun Huang, Brian Ebarvia, and Owen Kearney.

The objective of the project is to provide information that will begin to address the following questions:

- Who are the future potential customers of intelligent-transportation-system (ITS) technology?
- What are their transportation needs?
- How can ITS meet their transportation needs?

Unlike past efforts, however, this project has estimated benefits by first identifying user needs. Two specific demographic groups, low-income individuals and the elderly are examined herein as possible future users of ITS applications because of their unique transportation requirements. The introduction of ITS to meet emerging transportation needs requiring nontraditional service is a large and complex issue. This project is intended to contribute to addressing that issue.

The personal transportation needs of the population of the United States remain firmly rooted in the need to have access to employment, education, health care, recreation, shopping, and other basic trip ends. These needs are currently met through a combination of modes, but most heavily through a reliance on the private automobile. About 96% of the passenger miles of local ground travel in the United States in 1994 were by passenger car, taxi, and light-duty vehicles. (United States Department of Transportation 1997a, p.15)

Various demographic and economic forces in the United States have begun to create a major change in the nature, quality, and quantity of transportation demanded. Some of these forces of change are:

- Aging of the population [45 million people over the age of 65 are expected by 2015, a growth of 39% from 1995] (United States Bureau of the Census 1996b)
- Mothers working outside of the home resulting in large numbers of children with no parents at home at school-closing time [in 1992, 77% of women aged 35-44 worked outside the home] (Rosenbloom 1995)
- More welfare mothers entering the work force (Edin and Lein 1997)
- More physically disabled people entering the work force as a result of the Americans with Disabilities Act

These forces of change will affect the transportation needs of several segments of society, many members of which are unable to drive personal automobiles. Among these people are likely to be the aged, the disabled, the young, and the poor. Their transportation needs will change over time and are not well defined. For example, in a recent focus group in an assisted-living facility in southeast Michigan, Richardson et al. (1998) found a wide range of

transportation needs among the elderly residents. They included a means of transportation to volunteering opportunities, personal business appointments, and various social and recreational activities that the existing paratransit service was inadequate in meeting. In addition, these elderly people desired a variety of intelligent-transportation-system technologies such as route-guidance systems for their drivers and pretrip planning information prior to making a trip to a restaurant or shopping to ensure handicapped-accessible entry.

Other than in the most densely populated cities, rail transit is not a viable transit alternative. Flexible routing and scheduling are required for many of the needs of the population segments discussed here. This usually requires small-vehicle-based transit. Traditional buses will probably be inadequate in meeting the needs of these groups because of personal physical limitations. The vehicles will need to accommodate the limitations of the riders. To better meet the transportation needs of these segments of society, it is likely that community-based non-traditional transit will be necessary, most likely in vehicles that are redesigns of automobiles or vans.

Demographics in the United States are changing, and it is expected that there will be an increased population of people unable to drive themselves. Based on a review of literature and input from the United States Department of Transportation Federal Transit Administration, the study team decided to focus on two groups, the elderly and low-income populations. Concentration on these two groups yields insights not only for them, but allows additional hypotheses concerning other groups to be developed. Many issues of the elderly parallel those of the physically handicapped; and many issues of the low-income population, particularly the welfare-to-work population, parallel those of mothers working outside the home.

Transportation of the elderly has become an increasingly important issue. As the United States moves into the twenty-first century, the elderly (age 65 and over) continue to be the fastest growing segment of the population. This segment has grown substantially in the twentieth century and will continue to rise well into the next, especially the "oldest old" group (age 85 and older).

According to the United States Census Bureau's middle projections, over 45 million people will be age 65 and over by 2015, and over 6 million will be age 85 or over (United States Bureau of the Census 1996b, p. 17). Over 75% of the elderly live in suburban/low-density areas (Camph 1995), where one must often rely on the automobile. Through the years they have depended on the automobile as their primary transportation choice, but as they age and lose their physical and cognitive facilities, other means of transportation will be necessary. Although only about 3% of trips by those over 65 are by transit, it often represents the only mode available to many older Americans (United States Department of Transportation 1997a). Without transportation alternatives, many elderly citizens with deteriorating skills will continue to drive the automobile and consequently pose safety risks to themselves and other drivers.

Although the travel characteristics of the low-income population have long been of interest, welfare reform in 1996 moved them to a place of greater urgency.[1] This reform requires welfare recipients to search for work either in the form of jobs or community service after receiving cash assistance for 24 months. The assistance will be terminated after a period of time no matter whether welfare recipients have found jobs or are able to keep the ones found. While many job opportunities will continue to be available in central cities and downtown areas that are well

[1] The Personal Responsibility and Work Opportunity Reconciliation Act of 1996 signed into law by President Clinton launched welfare reform in ending the federal government's open-ended commitment to needy families through the Aid to Families with Dependent Children program (AFDC). The AFDC program was replaced by a new program, Temporary Assistance to Needy Families (TANF), which provides block grants to state governments to support needy families on a time-limited basis (Rich and Coughlin 1998).

served by transit, the growth of new jobs in suburban locations that are difficult, and often impossible, to reach by "conventional transit services" poses an increasingly important access issue. This issue is critical in the success of the welfare-to-work transition. This study includes not only those in the welfare-to-work transition, but also those already in the work force.

In sum, economic and demographic changes over the next twenty years will result in an increase in segments of the population that are unable to provide their own transportation. In order to be prepared to meet the transportation needs of these people, it is necessary to first define these needs. A tremendous amount of work has been done on this topic. This study expands on those efforts by noting trends, presenting results of focus groups, specifying transit attributes required by different population groups, and synthesizing the results.

The following sections include a description of the study methodology and findings from a literature search on the transportation needs of the low-income and elderly populations and proposed and implemented solutions to those needs. Results of focus groups and interviews with the elderly and low-income people and their service providers are then presented. These are followed by the study conclusions, references, and appendices.

II. APPROACH AND METHODOLOGY

In order to meet the project objectives, several tasks were undertaken. These include:

- Groups in society that are unable to meet their transportation needs were identified. This was done by reviewing economic and demographic trends and through discussions with knowledgeable people. These included Edward Thomas, Associate Administrator for Research, Demonstration, and Innovation of the Federal Transit Administration of the United States Department of Transportation, Professor Katharine Warner of the Department of Urban Planning, of the University of Michigan, and Richard Wallace, Research Assistant at the University of Michigan ITS Research Center of Excellence.

- A literature search was performed on material related to the transportation needs of the elderly and low-income groups. Material sources included the University of Michigan Transportation Research Institute Library, University of Michigan Libraries, sites on the World Wide Web, and bibliographies of documents reviewed. Over 500 documents were reviewed.

- Focus groups and interviews were conducted with elderly and low-income people and their service providers. These were done to identify their transportation needs and to obtain their suggestions on what type of transportation improvements, focusing on new technologies might best meet those needs. The focus groups and interviews were conducted in southeast Michigan.

- The information collected from the focus groups and interviews was analyzed by tabularizing the data, combining information from the literature search, and matching desired transportation attributes with characteristics provided by various intelligent transportation system (ITS) options.

III. LITERATURE SEARCH

A. Transportation Needs of the Elderly

In many suburban/low-density areas, existing transit services do not respond to the needs of the elderly. In fact, very few transit/paratransit options provide the mobility of the automobile (Rosenbloom 1993b, p. 303). The elderly (aged 65 or older unless otherwise noted) have grown accustomed to certain lifestyles that are shaped by a changing society with a great emphasis on mobility. In order to maintain their well being and quality of life, it is essential for the elderly to maintain their mobility. Mobility allows the elderly to interact with family and friends, remain active in the community, gain access to health care, and, in general, to remain more self-sufficient.

Traditional solutions such as adding more transit or paratransit service, or developing new technology do not always take into account the needs of the elderly. To meet the safety and mobility challenges of transportation of the elderly, it is imperative to understand the characteristics of the elderly and how they define their own transportation needs.

1. Characteristics of the elderly population

The elderly of today in the United States differ from those of the past. They live longer, come from different racial and cultural backgrounds, are more educated, and have greater economic resources. Many senior citizens participate in social activities, recreation, athletics, and community services, as well as other activities that senior citizens in the past would not even think of doing. The trend of an increasingly active senior population was identified over twenty years ago. "The consequences of improved health, economic independence, and education will be to permit and encourage a variety of 'lifestyles' among the future elderly which will, in simple terms, be drawn from more diverse experiences in younger life as well as from greater freedom of choice in retirement." (Wachs 1975, p.5).

Several characteristics have contributed to a more active, varied lifestyle and have influenced the transportation needs of the elderly: longer life span, diversity, more education, more disposable income, greater dependence on the automobile, and a greater likelihood of living in a suburban/low-density area.

a. Living Longer

The elderly are the fastest growing segment of the United States population. According to the United States Bureau of the Census, the number of persons under the age of 65 has tripled from 1900 to 1994, while the number of persons aged 65 or over has increased by a factor of 11 (United States Bureau of the Census 1996b, p. 2-2). In 1994, the elderly made up one in eight in the United States (33.2 million). Between the years 2010 and 2030, the elderly population is expected to increase by an average of 2.8% annually, when the "baby boom" generation reaches their elderly years. By 2050, as many as one in five Americans could be elderly (80 million), and 24% of the elderly will be age 85 and over. People are living longer today than in 1950, when the life expectancy was 68 years. In 1991, life expectancy for women was 79 and for men 72 (United States Bureau of the Census 1996b, p. 3-1).

b. More Diverse

Race and ethnicity play a significant role in the lifestyles of the elderly, and thus influence their transportation needs. Language and cultural barriers need to be taken into account as demand increases for general route information, schedules, and marketing material appropriate to diverse populations (National Eldercare Institute on Transportation 1994a, p. 3).

In 1994, 13% of elderly were a race other than White. This is expected to increase to 23% by 2050 (16% Hispanic; 10% Black; and 7% Asian/Pacific Islander; less than 1% Native American, Eskimo, and Aleut) (United States Bureau of the Census 1996b). Cultural or ethnic differences may create variations in the driving patterns of older people as well as in the kind and amount of ride-giving either requested by or provided to them (Rosenbloom 1994, p. 5). A study in Los Angeles found that Hispanics relied on their family for transportation far more than White and Black elderly of similar socioeconomic status. Whites and Blacks, conversely, were more likely to drive to meet their travel needs (Rosenbloom 1994, p. 5)

c. More Educated

The United States Bureau of the Census states, "Improvements in educational attainment are likely to make notable differences in the interests of the future elderly, their needs, and abilities." Education will also influence the transportation needs and choices of the elderly. The education level of the elderly will determine, in part, the use of sophisticated technology. In 1993, only 60% of those over 65 had completed high school, while 80% of those under 65 had. Nearly 8 in 10 persons aged 55 through 59 had at least a high school education, as did nearly 9 in 10 between the ages of 40 and 49. Also, while only 12% of the elderly in 1993 had college degrees, 20% between 55 and 59 and 27% between 40 and 49 did. As the under-65 population enters senior-citizen status, the education attainment level will continue to increase (United States Bureau of the Census 1996b, pp. 6-15 - 6-19).

d. More Disposable Income

In constant 1992 dollars, the median income for elderly White men in 1992 was $14,548, more than double the $6,537 in 1957 (median income for White women increased from $3,409 to $8,189 during the same period) (United States Bureau of the Census 1996b, pp. 4-8). The increase in income creates an elderly market with more disposable income and greater spending opportunity.

Income, however, varies by factors such as age, race, sex, marital status, education, living arrangements, and work history. The combined median income of Black and Hispanic women in 1992 ($6,220 and $5,998, respectively) was less than the total for the White elderly male (United States Bureau of the Census 1996b, pp. 4-8).

More and more men in the United States are retiring at an earlier age. In 1992, 26% of men aged 65 to 69 worked, while, in 1950, 60% did. For women 65 and over, labor participation rates have remained low for decades (10% in 1950; 10% in 1967; 8% in 1993). Elderly women (as well as men) often reduce the length of their work week and number of weeks they work in a year (United States Bureau of the Census 1996b, p. 4-1). This decline in employment reduces the number of persons requiring work-related trips, but work-related trips account for only 25% of all trips made. The elderly will have other transportation needs, such as visiting relatives, going to church, and shopping (National Eldercare Institute on Transportation 1994a, p. 3).

e. More Likely to Depend on Private/Auto Transportation

Most elderly have relied on automobiles for the majority of their lives. They rely on automobiles for approximately 90% of their trips, even though more than 30% of the elderly lack a driver's license. If they are not driving, they rely on friends or relatives to drive them (United States Department of Transportation 1994).

f. More Likely to Live in a Suburban/Low-Density Area

The elderly are aging in place. Those over 65 today are almost half as likely to move after retirement as they were 30 years ago (Rosenbloom 1988, p. 26-27). Currently, over 75% of the elderly live in suburban/low-density areas (Camph 1995). In suburban/low-density areas, the automobile is required to access services such as shopping and medical care. This has influenced the elderly to rely on automobiles for mobility. Access to automobiles allows the elderly to live in low-density areas with little or no transportation alternatives, thus creating a cycle of continued automobile dependence.

2. Reported trip purposes

With a decreasing elderly workforce, work-related trips will continue to decline, but travel by the elderly will not necessarily decline. With a more active elderly population, the elderly have more transportation needs and random travel patterns (Coughlin and Lacombe 1997, p. 93). The elderly demand transportation access to shopping, medical care, church, work, and social/recreational activities, and to visit family and friends.

Numerous studies have been done on the transportation needs of the elderly, and have shown that the elderly continue to have transportation needs after employment. Table 1 shows a comparison of three studies done on trip purposes of the elderly.

In the 1977 Nationwide Personal Transportation Survey (NPTS), Roskin (1980) found that 49.6% of the vehicle trips of drivers over the age of 70 were for family and personal business purposes and only 8.0% were for earning a living. Social and recreational trip purposes comprised 25.2% of all trip purposes made by this age group.

Recent studies have supported the 1977 NPTS and have showed an increasing trend of nonwork related trips made by the elderly. In the 1990 NPTS, trips made by those age 65 and older were for the following purposes: earning a living (5.5%), family and personal business (including medical trips; 57.2%), civic, educational, and religious (8.5%), and social and recreational (27.3%) (United States Department of Transportation 1994). This shows a decreasing trend in work-related trips by the elderly, as well as increases in family and personal business trips and social and recreational trips. In a stated preference interview conducted in Oakland County, Michigan, from 1995-1997, groups consisting of assisted-living elderly and FAST-TRAC (Faster and Safer Travel through Traffic Routing and Advanced Controls) field-test participants age 67 to 96 ranked health care as the most important transportation need, followed by shopping, recreation, socializing, religion, personal business, employment, and education (Richardson et al. 1998, p.14). Those aged 65 to 74 ranked shopping as the most important transportation need, with health care ranked third. In the 75 to 84 age group and the 85 and above age group, health care ranked first and shopping ranked second.

While the three studies show similar frequency and importance of nonwork-related trips, they show a difference between the reported trip purpose and the preference of medical and health-care-related trips. In the 1977 NPTS, the elderly reported approximately 3% of trips to be

related to medical purposes, but when asked to rank the importance of health care trips in the FAST-TRAC study, health care was ranked the most important. While the elderly make less frequent medical/health-care-related trips, this is an indication of the value the elderly place on medical/health-care transportation.

As the elderly population changes and increases, transportation for nonwork-related purposes becomes even more necessary. Over 90% of the elderly depend on private vehicles as their mode of transportation, but once that option is lost, they have little or no alternatives.

Table 1. Reported Trip Purposes of Elderly

1977 NPTS (age of driver: over 70)	**1990 NPTS (age 65 +)**	**1995-1997 FAST-TRAC Field Test Stated Preference Interviews** (ranking of importance from 26 people between ages 67-96; 1 is most important, 10 is least important)			
		Overall (n=26)	65-74 (n=5)	75-84 (n=9)	85-96 (n=12)
Earning a Living (8.0%)	Earning a Living (5.5%)	Health Care (2.1)	Shopping (2.6)	Health Care (1.5)	Health Care (1.5)
Family and Personal Business (49.6%)	Family and Personal Business (57.2%; Medical & Dental trips: 2.9%)	Shopping (3.0)	Recreation (3.4)	Shopping (3.1)	Shopping (3.2)
Civic, Educational, and Religious (9.9%)	Civic, Educational, and Religious (8.5%)	Recreation (4.2)	Health Care (3.6)	Recreation (3.7)	Socializing (3.2)
Social and Recreational (25.2%)	Social and Recreational (27.3%)	Socializing (4.2)	Religion (3.8)	Personal Business (5.0)	Religion (4.3)
Other and Unknown (7.3%)	Other and Unknown (1.5%)	Religion (4.6)	Personal Business (4.8)	Socializing (5.2)	Recreation (4.8)
		Personal Business (4.9)	Socializing (5.0)	Religion (5.4)	Personal Business (4.9)
		Employ/ job training (6.3)	Employ/ job training (5.6)	Employ/ job training (6.1)	Employ/ job training (6.8)
		Education (6.7)	Education (6.6)	Education (6.4)	Education (6.8)

Sources: Roskin (1980), p. 66, United States Department of Transportation (1994); Richardson et al. (1998), p. 14.

3. Difficulties/issues in meeting transportation needs

The elderly expect to continue social, recreational, and personal business shaped by the cultural, ethnic, and economic factors of their lifestyles. They desire to maintain independence, dignity, emotional well being, and freedom from friends and family for their transportation needs, which the automobile has given them. Maintenance of quality of life for the elderly requires that their transportation needs be met.

a. Dependence on the Private Vehicle

One main barrier to meeting the transportation needs of the elderly is their dependence on the automobile. While the automobile has increased the number of miles traveled and number of trips, its use has cyclically forced the elderly to depend almost exclusively on the automobile. The automobile has allowed them to function in suburbs and low-density areas. The 1990 Nationwide Personal Transportation Study estimated that over 90% of men and almost 80% of women over 70 were licensed drivers, and that licensing of the next generation of those over 65 will be universal (United States Department of Transportation 1994). This trend is supported by Zhou and Lyles (1997) who report that the next generation of older people is likely to increase their dependence on automobiles as drivers.

The automobile has increased the mobility of the elderly, measured by the number and distance of trips taken. The elderly took 6% more trips in 1990 than in 1983, and those trips were 19.4 % longer. The average annual miles driven by elderly aged 65 through 69 rose from 6,804 miles in 1983 to 8,290 in 1990, and, for those over 70, the average annual miles driven rose from 4,348 to 6,264. Despite not having lengthy work trips, even those over 85 were driving an average of 54 miles per week, whereas those 70 through 74 were driving 140 miles per week (United States Department of Transportation 1994).

The elderly of the United States have grown accustomed to private vehicles, not unlike the rest of the United States population. This has given the elderly freedom and personal mobility to go anywhere at any time. However, once an elderly person can no longer drive because of declining physical and cognitive skills his/her mobility decreases. Even if alternative transportation exists in the area, elderly people formerly reliant on cars must learn how to use public transportation and deal with the loss of freedom from no longer driving (Heckmann 1997). Public transportation cannot match the mobility and freedom afforded by the automobile.

To the elderly, the automobile also represents independence, dignity, and well being (Coughlin and Lacombe 1997, p. 97). For many elderly, the automobile is their last symbol of independence. Many elderly individuals hold onto their licenses as long as possible out of fear of losing independence, regardless of age or disability (Rosenbloom 1993b, p. 303). Those who still drive avoid high-risk situations such as peak-period traffic, nighttime driving, and poor weather (Rosenbloom 1993b, p. 303; Institute of Transportation Engineers 1994, p. 6-8; United States Department of Transportation 1997, p. 23). Some even continue to pay insurance, maintenance, and fuel despite no longer driving (Coughlin and Lacombe 1997, p. 97).

b. Suburban Areas and Travel Patterns

Currently, over 75% of the entire American elderly population live in low-density suburban or rural areas, where most depend on the automobile as their means of transportation, and traditional fixed-route public transportation is inefficient and costly. According to a *New York Times* article, more older people are living in the suburbs than ever before, and "for an increasing number of the suburban elderly, driving to supermarkets, libraries, and shops, once a

routine of daily life, is now simply impossible" (Fein 1994). Higher income, the ability to drive, and living in suburban or low-density areas with little or no alternatives explain the travel patterns of the elderly. The elderly travel primarily suburb to suburb for shopping, social activities, and other nonwork related trips, and these trips vary in time and distance (United States Bureau of the Census 1996b).

Zhou and Lyles (1997) compared the mobility patterns of today's elderly with those predicted for the next generation of older people. They found that while making fewer trips, suburban older people are making considerably longer trips. They estimate that the next generation of older people will travel just less than 5 miles per day further than current older people. Their key finding is that as the elderly continue to shift to rural areas, small cities, and suburbs, there is likely to be increased per capita travel (i.e., higher exposure), although they will make fewer trips.

c. Inadequate Service

Elderly people's travel patterns cannot be met by traditional transit services. Traditional transit services lack the flexibility in scheduling and routing to meet the elderly's needs. While many alternatives may exist in the form of community-based systems or informal systems (family and neighbors), they are fragmented, uncoordinated, and not universally available (United States Department of Transportation 1997a). A study for the National Research Council in 1988 found that traditional fixed-route service does not serve the widely spread travel patterns of the suburban elderly population because the service focuses on work trips and downtown areas. Because suburban trips are so long and varied, increasing service coverage does not improve transportation. The study also found that between 30% and 60% of suburban elderly persons could not make desired one-way trips using public transit in under 30 minutes even with almost perfect service. For these reasons, very few elderly take public transit. In 1990, those aged 65 through 74 used public transit for 1.0% of their trips; those aged 75 through 84 and those 85 and above used public transit for only 1.8% and 3.2% of their total trips, respectively. The lack of information on using public transit for the elderly has also deterred the use of public transit (United States Department of Transportation 1994a).

d. Mobility-Related Disabilities

Another barrier to elderly travel is physical disability. Of the more than 30 million elderly citizens in the United States, 5 million (16%) report some "mobility limitation", or a condition that has lasted six or more months and results in difficulty going outside the home (United States Department of Transportation 1994). About half of these are "self care" impairments, conditions that have "lasted six or more months and which make it difficult for the elderly to take care of their own personal needs" (National Eldercare Institute on Transportation 1994a).

The ability to drive safely decreases as age and physical disability increase. Age and physical decline also limit the speed and distance the elderly can walk and use public transit. Obstacles such as hills and crossings have limited pedestrian travel for 30 to 50% of ambulant disabled people (Mitchell 1997). Steps and crowds as well as accessibility to buses, trains, and other vehicles that are poorly designed for disabled and elderly people hinder mobility. Another obstacle for vision-impaired people is the lack of, or inaccessibility to, information regarding public transit, such as difficult-to-read time schedules, unclear announcements of stops, and small signs on vehicles indicating routes (Golledge et al. 1996).

The 1990 Americans with Disabilities Act (ADA) may have also limited mobility for the elderly. While the ADA provides complementary high-level paratransit service to those with disabilities,

the tight eligibility standards put some elderly citizens at a disadvantage. Many elderly do not meet the standards, but require special service not met by the ADA due to declining physical and cognitive abilities, such as difficulty in entering and exiting buses, and poor eyesight (Rosenbloom 1993a).

While physical limitations may hinder the elderly population's ability to travel, they may also affect their desire to travel to engage in activities. A 1988 National Research Council study noted: "It is important to understand both the barriers that reduce the older person's desire to travel and those that reduce their ability to travel when they still wish to do so. Such a separation is not easy; the same physical problems that cause the elderly to reduce their driving could rob them of the ability to engage in activities at their destinations." (Rosenbloom 1988a, p. 49-50).

e. Safety and Security

The issue of elderly driving and accidents has been well documented. Knoblauch et al. (1997) identified characteristics of older drivers that affect their ability to drive on freeways. The United States Department of Transportation (1997a) has also discussed the driving ability of the elderly, reporting that for most older people, maturity and experience typically compensate for declining skills. In general, older adults reduce their driving as their skills decrease. Some discontinue driving due to sudden illness, but many withdraw gradually and responsibly by driving less frequently and/or avoiding driving under difficult conditions (e.g., nighttime, rush hours, bad weather, unfamiliar places, and high-speed highways). A small number of people, however, continue to drive despite deteriorated judgements. The highly publicized crashes of this small subset may give an incorrect impression of the driving behavior of the entire elderly population.

As noted earlier, however, the elderly will increase travel and are expected to maintain (if not increase) dependence on the automobile and travel longer distances. The United States Department of Transportation (1997a) also reported that, based on crash rate per vehicle miles driven and fatality rate per 100 million vehicle miles traveled, there is a greater elderly safety problem. Some older drivers may avoid night driving, but this may not lead to less travel. While overall accident rates should remain the same or drop slightly for the older person, their greater travel exposure will likely contribute to significant increases in the absolute number of accidents for older people in the future. This evidence along with crash data indicates an increasing safety problem (Zhou and Lyles 1997).

To gain a better understanding of the elderly and driving accidents, Waller (1998) defined three methods to calculate crash risk: crash risk per licensed driver, crash risk per miles driven, and crash fatality rates by population. The significance of accidents and the elderly varies depending on the method and data used.

As shown in figure 1, older drivers appear to be safer than any other age group based on crashes per 1,000 licensed drivers. The highest rates were for drivers under age 20 (United States Department of Transportation 1997a).

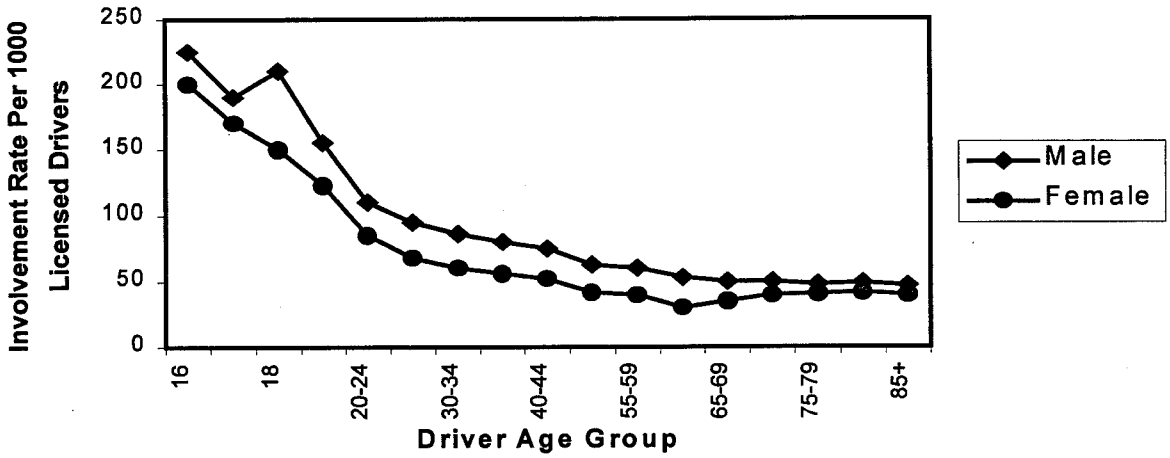

Figure 1 - Crash Involvement Per 1,000 licensed Drivers
Source: United States Department of Transportation (1997a).

When measured by vehicle miles traveled, however, crash fatality risk begins to rise in drivers' late fifties and increases at an accelerating rate thereafter. Figure 2 shows this increase occurs despite evidence that, as a group, older drivers drive much less than other drivers and try to restrict themselves to the safest times and places (United States Department of Transportation 1997a). The United States Department of Transportation (1998) and Waller (1996) both report that crash rates based on mileage increase with increasing age, and the probability of the older driver being found at fault increases; in as many as 80% of multivehicle crashes, the older driver is found at fault.

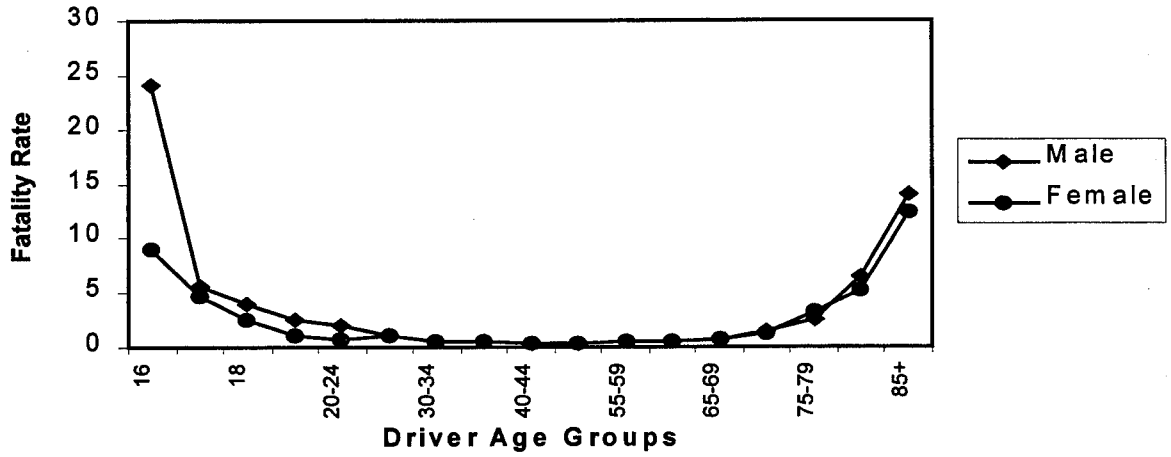

Figure 2. Driver Fatality Rate Per 100 Million VMT, 1994
Source: United States Department of Transportation (1997a).

When traffic fatalities are considered independently of other causes of death, population rates show marked increases in crash fatalities among the elderly (see figure 3). The United States Department of Transportation (1998) reported that the fatality rate for all 16 through 20 year olds in 1997 was 34 per 100 thousand population and continues to decrease with age, with the

lowest fatality rate occurring at ages 55 through 64 (approximately 12 per 100 thousand population). Beginning at age group 65 through 69, however, the fatality rate increases dramatically. The fatality rate at 65 through 69 is 14 per 100 thousand population, but at ages 70 through 79, the rate increases to almost 20 per 100 thousand population and to over 25 deaths per 100 thousand population for those 80 years old and over.

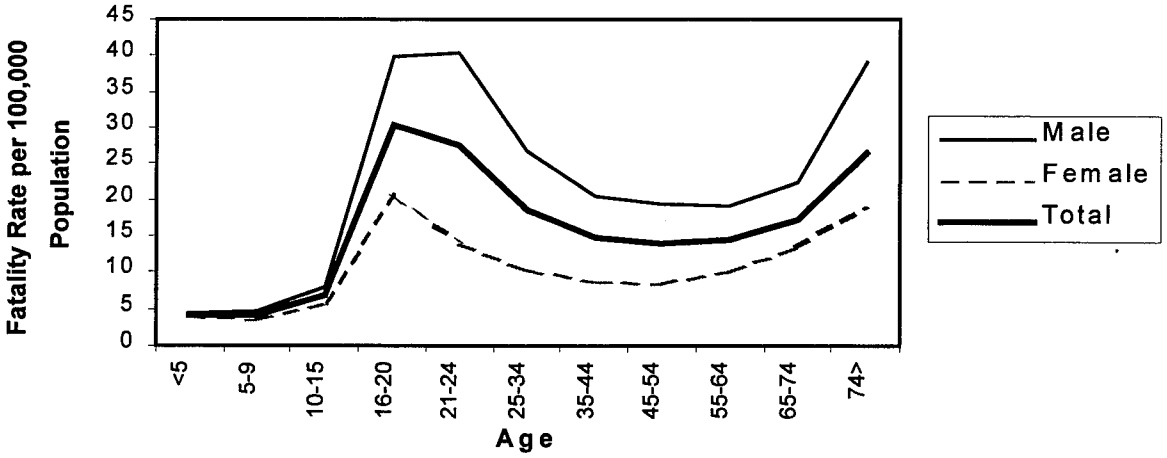

Figure 3. Crash Fatality Rates by Population, 1997
Source: U. S. Department of Transportation (1998).

Another measure used to calculate elderly crash risk is the age/fragility relationship – fatalities per 1,000 crashes (Transportation Research Board 1988), shown in figure 4. A significantly greater percentage of crashes result in fatalities beginning at the 60-through-64 age group. From age 15 to 59, the rate remains near 2 fatalities per 1,000 crashes. At ages 60 to 64, the rate increases to approximately 3 fatalities per 1,000 crashes, and increases steadily to 5 between the 65-through-69 and 75-through-79 age groups. Beginning at the age of 80 and over, the fatality rate per 1,000 crashes sharply increases to 8 fatalities per 1,000 crashes.

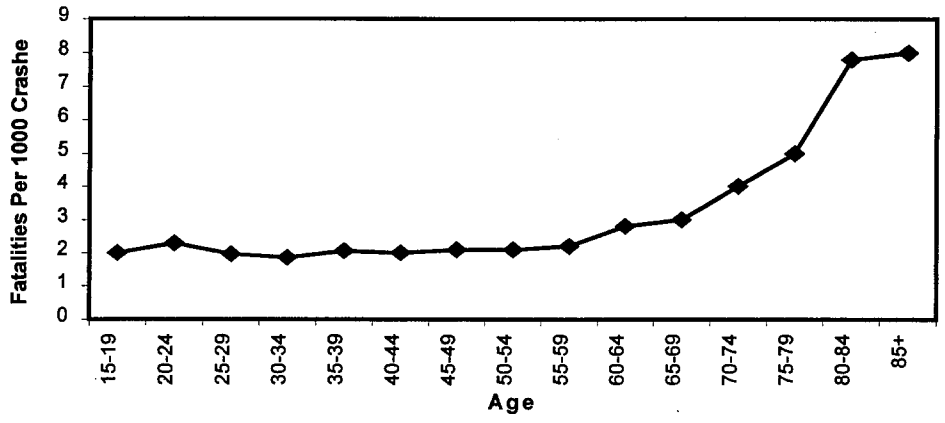

Figure 4. Age/Fragility Relationship. Fatalities Per 1,000 Crashes, 1983
Source: Transportation Research Board (1998).

These data suggest that, despite fewer crashes per 1,000 licensed drivers, the elderly have an increasing safety problem. Elderly drivers pose greater safety risks based on driver fatality rate

per 100 million vehicle miles traveled and crash fatality rates by population. In addition, a greater percentage of elderly crashes result in a fatality.

Traditional public transit has its service drawbacks for the elderly population, but many elderly do not use public transportation due to fear and perception of lack of security. Many elderly fear becoming injured or victims of crime in crowded buses. The elderly also do not use public transit for reasons such as lack of shelters, dirty windows that compromise failing eyesight, and unsympathetic drivers (Rittner 1995).

4. Summary

A growing elderly population with emerging characteristics indicates that current transportation does not meet the needs of the elderly. Increased life expectancy, diversity, education, greater economic resources, dependence on the automobile, and residency in suburban and rural areas have changed the elderly lifestyle, creating a more active elderly population with greater transportation needs and random travel patterns.

Studies have shown that transportation for the elderly must focus on nonwork related trips. Most elderly trip destinations are for shopping, social, and recreational/leisure purposes. The trend of increasing vehicle miles traveled, number of trips, and dependence on private vehicles will only intensify as the elderly population grows.

There are difficulties and issues, however, that impede meeting the transportation needs of the elderly. The elderly population's dependence on the private vehicle, residence in suburban and rural areas, random travel patterns, personal physical limitations, and safety issues have made it difficult for traditional transit to adequately meet the needs of the elderly.

B. Transportation Needs of the Low-Income Population

The transportation needs of the low-income population are closely interrelated with those of women, single parents, inner-city residents, and those transitioning from welfare to work. This section includes those populations in its scope.

Ornati (1969) noted that while there was abundant literature on the social benefits of high labor mobility, the inability of the urban poor to travel to work was not considered until the McCone Commission on the Watts Riot of the late 1960s. The Commission recognized the difficulties that Watts-area residents had in getting to work as a cause of the riot. Ornati (1969) and Falcocchio and Cantilli (1974) pointed out the issue of the inadequate mobility of low-income people and its relationship to the unemployment problem of the 1960s. Although their work primarily focused on transportation needs of the urban poor, they also asserted that the relationships between transportation deficiencies and economically disadvantaged people were not less significant for rural areas. In fact, Maggied (1982) further studied the economic aspects of available transportation as a determinant of the employment status of Georgia's rural poor and concluded that limited personal mobility impedes access to work activities, which in turn determine personal income. These earlier researchers all recognized the overall dilemma of low-income workers: They were forced either to pay more for transportation (i.e., purchasing a car) to get to a higher-paying job inaccessible by public transit or accept a low-paying job served by transit. Most of the time, neither job would be attractive enough to induce unemployed workers to invest money or time from their meager budgets to become employed.

Three decades later in 1996, welfare reform drew greater attention to the transportation needs of the low-income population. Adequate and affordable transportation to get low-income people

to work has not been made available. Although some aspects of their transportation needs can be understood through studying transportation characteristics such as travel patterns, travel modes, and trip purposes, researchers are paying more attention to particular transportation needs originating from the socioeconomic characteristics of the low-income population. Characteristics such as gender, family status, and nature of entry-level jobs create challenges to low-income people in meeting their transportation needs. The importance of these characteristics is reflected in their inclusion in this study.

1. Profile of low-income population

Kostyniuk et al. (1989) noted that, in 1979, 87% of the single-parent families in the United States were headed by women, and 45% of this group had incomes below the poverty level. Currently, more than 90% of welfare parents are single mothers (Urban Institute 1997). The following two sections present a more detailed profile of the low-income and welfare population. They consistently show that there is a great deal of overlap between the transportation needs of single mothers and people of low income. Many welfare and low-income mothers face strenuous daily commutes that have impacts on their children and make it difficult for them to retain employment.

Traditional research on transportation needs did not often look at the needs emerging from the gender and family status of the low-income population. This makes it difficult to understand the needs of the low-income population, especially when the needs of women and the low-income population sometimes contradict each other. An example of this is the willingness to carpool or vanpool evidenced in the survey data from three cities in Louisiana (Nwokolo 1990). The survey data showed that low-income people were more interested in carpooling or vanpooling than were high-income people. However, women were found less supportive than men of carpooling or vanpooling. It was unclear in the survey report what the attitudes of low-income women toward carpooling and vanpooling were.

a. Detailed Profile of the Low-Income Population

The Institute for Research on Poverty (1998) noted that the overall poverty rate and the poverty rates of individuals in certain demographic subgroups differ substantially. Appendix A shows that, in 1996, the poverty rates of Blacks, female-headed families with children, Hispanics, and children greatly exceeded the average. Female-headed families with children constituted 44.3% of the 36.5 million people living in poverty, which accounted for 13.7% of the total United States population in 1996. Appendix B shows that, during the 1959-to-1996 period, the poverty rate of female-headed families doubled from 26.3% to 53.5%, while those of many other demographic groups decreased or stagnated. Appendix C shows that female-headed families with children and unrelated individuals (individuals living alone) are more likely to be poor than other families with children or families with aged members. In 1996, 42.3% of female-headed families with children were poor, compared with 8.5% of male-present families.

b. Profile of the Welfare Population:

The nation's welfare population has three major characteristics: The majority of adult welfare recipients are single mothers; about half of these mothers have children younger than school age; and more than three-fourths have only a high school diploma or less. Ninety percent of Temporary Assistance for Needy Families (TANF) are headed by single females without male adults in household. Many single mothers had their first child when they were teens; more than 40% of mothers have only one child; and 74% have only one or two children. The youngest

child is less than 5 years old in 50% of the TANF families, 6 to 11 years old in 30%, and at least 12 years old in 20% of them (Urban Institute 1997 and Lacombe 1998).

Recent data on low-income people show that poverty has significantly increased in female-headed families and for individuals in these families from 1970 to 1990. Almost half of the group lived in poverty in 1996. The group is also the most dominant group of the welfare population whose lifestyle has been significantly affected since welfare reform in 1996.

2. Reported travel characteristics of low-income population

Based on the American Household Surveys (AHS), Pisarski (1992) showed that the low-income population[2] made most of their work trips in 1985 and 1989 by driving alone. The next most common means were carpooling, walking, and transit, as illustrated in figure 5. This figure also suggested the increasing affordability of personal vehicle travel and access to private vehicles among the low-income population, accompanied by decreasing use of carpooling, walking, and transit, along with a slightly increasing use of taxi and bike. However, Pisarski (1992) commented that although the actual transit use reported in the AHS declined by 26% from 1985 to 1989 in the low-income population, the trend is not as dramatic as it might appear because the number of workers in that group declined by 7% in that period.

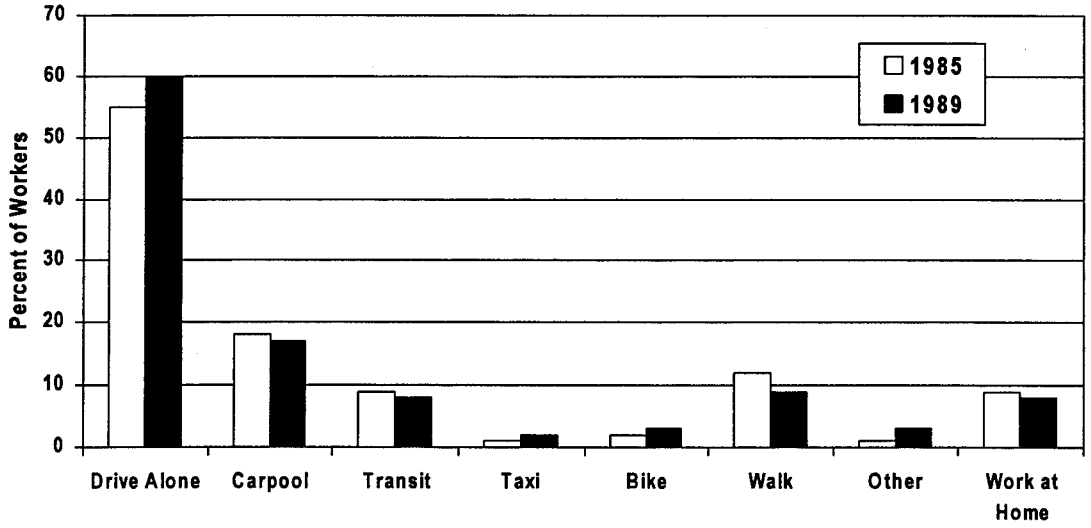

Figure 5. Mode Choice of the Poverty Population for Work Trips, 1985 and 1989
Source: Pisarski (1992), figure 18.

a. Reported Travel Modes

This section presents selected reported modal choices based on both local and national data. Taylor and Sen (1976) conducted a survey from May 24 to July 28, 1974 on the travel habits and preferences of a sample of 50 recipients of Aid to Families with Dependent Children in Syracuse, New York. Trip diaries provided information on the home, modes, and purposes of their travel. In analyzing all income groups, Altshuler et al. (1979) focused their research on the travel characteristics by income class and the relationship among mobility, income, and automobile ownership based on the 1969 Nationwide Personal Transportation Survey (NPTS) and 1970 census data. The lowest-income group was below $5,000 based on 1970 dollars.

[2] Poverty was defined in 1989 as a family of four with an annual income of less than $12,674.

Two decades later, Hu and Young (1994) produced the *1990 NPTS Databook* based on 1983 and 1990 NPTS data. As expected, the cutoff level for definition of the lowest-income group rose from the $5,000 defined by Altshuler et al. to $10,000 based on 1990 dollars. The most recent source for understanding low-income people's travel behavior is *Daily Travel by Persons with Low Income* by Murakami and Young (1997). This report defined low-income households in the 1995 NPTS data as those with one to two persons making a household income under $10,000, those with three to four persons with a household income under $20,000, and those with more than five persons with household income under $25,000. As a result, 4,271 households in the 1995 NPTS are classified as low-income, and 539 households are classified as single-parent, low-income households. They also note a lower accuracy of data on low-income households' travel behaviors due to underreporting of data resulting from a lack of continuous phone service in over 30% of the households receiving welfare. They concluded that five modes of transportation are primarily used by low-income people. These are automobiles, buses, taxis, carpool or vanpool, and walking.

(1) Automobile as primary mode

Taylor and Sen's survey (1976) found that automobiles (individually or as a passenger) were the primary mode used by low-income people, followed by buses and walking. The dominant mode of travel after 5:00 p.m. was as a car passenger in someone else's car, while very few trips were made as a car driver. Most of the car drivers in this low-income group borrowed a car from relatives, friends, or neighbors. Table 2 shows that even in the income group less than $5,000, about 85% of the trips are by automobile; 37.8% are as passengers; and 47.6% are as drivers. Low-income groups' percentage of trips as automobile drivers is slightly higher than that as passengers. The difference increases as income increases. Both Taylor and Sen (1976) and Altshuler et al. (1979) showed that low-income groups relied on automobiles as their primary transportation mode and were more likely to be passengers than drivers compared with other income groups. However, low-income households travel much less than other income groups. Table 3 shows that, in 1969, they accounted for 12.1% of all travelers, 10.1% of all automobile drivers, and 12.7% of automobile passengers while they constitute 28.4% of all households.

Table 2. Modal Distribution for Urban Travel by Income Class, 1969

	Mode						
Income Class	**Auto Driver**	**Auto Passenger**	**Bus or Streetcar**	**Subway or Elevated**	**Commuter Rail**	**Taxi**	**Total All Modes**
<$5,000	47.6%	37.8%	12.2%	1.5%	0%	.8%	100%
$5,000 – $7,499	55.8%	37.0%	5.5%	1.4%	.1%	.2%	100%
$7,500 – $9,999	57.6%	38.3%	2.5%	1.0%	.2%	.5%	100%
$10,000 - $14,999	60.3%	36.0%	2.4%	.9%	.3%	.2%	100%
>$15,000	60.7%	34.0%	3.1%	1.6%	.3%	.3%	100%
All Incomes Total	57.3%	36.6%	4.4%	1.2%	.2%	.3%	100%

*Each figure in the table represents the percentage of the total trips made by each income group accounted for by the indicated mode. Source: Altshuler et al. (1979), p.23.[3]

Table 3. The Composition of Urban Transportation Mode, Riders by Income Class

[3] Original Source: Pucher, John. 1978. *Equity in Transit Financing* (PHD. Diss. MIT, 1978), p. 28. The distributions were calculated from a computer tape of the 1970 National Personal Transportation Study Supplied by the Federal Highway Administration, United States Department of Transportation.

(United States Aggregate, All Purposes, 1969)

	Income Class				
Travelers By Mode	**<$5,000**	**$5,000 – $9,999**	**$10,000 - $14,999**	**>$15,000**	**All Incomes**
All Household in the United States, 1970 *	28.4%	30.9%	23.0%	17.6%	100%
All Travelers	12.1%	42.0%	29.6%	16.2%	100%
Auto Drivers	10.1%	41.6%	31.1%	17.2%	100%
Auto Passengers	12.7%	43.2%	29.1%	15.1%	100%
Bus or Streetcar Riders	34.1%	37.8%	16.4%	11.6%	100%
Subway or Elevated Riders	14.9%	42.8%	21.2%	21.1%	100%
Commuter Rail Riders	0%	35.1%	39.6%	25.2%	100%
Taxi Passengers	28.5%	42.3%	16.0%	13.3%	100%
Public Transportation Users (All Modes)	27.6%	37.1%	18.0%	17.7%	100%

*The first line displays the percentage of all United States households in each income group. Other lines display the percentage of the total riders of each mode accounted for by each income group.
Source: Altshuler et al. (1979), p. 23. [4]

Appendices D and E provide detailed data by income group. Appendix F summarizes some of these data for the lowest income group. Appendix F shows that the lowest income group (less than $10,000) in 1990 made 41.6% of their total trips by driving a car or a van, 21.0% by being car or van passengers, 3.4% by bus and streetcar, 0.3% by rail and subway, and 0.5% by taxi. These figures are not comparable with those in table 2 because the modal distribution percentage in 1970 was for trips made only by automobile, bus, streetcar, subway, commuter rail, and taxi, while the 1990 data include other modes. In addition, the lowest income group in table 2 (1969 urban data) has an income under $5,000 based on 1970 dollars while that in appendix F (1990 national data) has an income under $10,000 based on 1990 dollars. Further, the 1969 data are urban, and the 1990 data are national. Also of note in appendix F is that the lowest income group also makes a significant amount of personal trips by pickup trucks and walking, which account for 7% and 21.3% of their total trips, respectively.

Appendix F also shows that, of the miles of travel of the lowest income group in 1990, 48.1% are by driving a car or a van, 31.2% by being car or van passengers, 11.7% by pickup truck, 3.1% by bus and streetcar, 0.5% by rail and subway, 1.8% by walking, 0.4% by biking, 2.1% by school bus, and 0.4% by taxi. Appendix E shows that the lower-income group in 1990 tended to have a higher percentage of miles of travel as car or van passengers than did higher-income groups. This is likely to be due to higher percapita private vehicle ownership by higher-income people.

[4] Original Source: Pucher, John. 1978. *Equity in Transit Financing*. P.24. The figures on distribution of all United States households by income class were calculated from United States Department of Commerce, Bureau of the Census, *1970 Census of Population, vol. PC(1)-D1: Detailed Characteristics*, United States Summary (Washington, D. C.: United States Government Printing Office, 1973), table 258. The aggregate public transportation income distribution was calculated from the NPTS by the FHWA and reported in Jose Gomez Ibanez, "Federal Assistance for Urban Mass Transportation" (PHD. Diss., John F. Kennedy School of Government, 1975), p.210. The reaming statistics in the table were calculated by John Pucher from a NPTS computer tape supplied by the Federal Highway Administration. Local trips were defined as those of fifty miles or less. Overnight trips and school bus trips were excluded regardless of length.

Murakami and Young (1997) reported that, for the work trip, 84% of trips by workers in 1995 in low-income households (compared with 90% in other households) were by private vehicles. Table 4 shows that low-income workers' average vehicle occupancy was somewhat higher than that of other income groups (1.85 versus 1.57).

Table 4. Average Vehicle Occupancy for Private Vehicle Trips (Weighted by Miles), 1995

	All Income Groups	Low-Income Group	Other (Not Low-Income Group)
Earning a Living	1.16	1.20	1.15
Family and Personal Business	1.77	2.01	1.74
Social and Recreational	2.07	2.48	2.07
TOTAL	1.59	1.85	1.57

*Not all trip purposes shown. Source: Murakami and Young (1997), table 7.

The 1995 NPTS data also show the same result found by researchers two decades earlier. Murakami and Young (1997) noted that person trips in low-income households are much more likely to be made as passengers in private vehicles than are the person trips in higher-income households. They maintained that part of this is attributable to the likelihood of there being more children in low-income households. Besides, they also found that these trips made in private vehicles are much more likely to be in "non-household" vehicles. As Taylor and Sen noted in 1976, these trips are more likely to be in the vehicles of friends, neighborhoods, or relatives. From the 1995 NPTS, these trips as passengers account for nearly 9% of private vehicle trips for low-income households and about 17% for low-income single-parent households, compared with less than 1% for other income households (Murakami and Young 1997).

As shown in table 5, Murakami and Young (1997) reported that 26% of low-income households and 36% of low-income, single-parent households did not have a car in 1995, compared with 4% of other households with higher levels of income. Low-income households not only have older vehicles (average age of 11 years old as opposed to 8 years old for other households), but also fewer vehicles per adult (0.7 versus 1). The authors concluded that not having access to a car is one of the key factors limiting the mobility of low-income persons.

(2) Carpool or Vanpool

As noted earlier, figure 5 shows that the low-income population made most of their work trips by driving alone, followed by carpool, walk, and transit in 1983 and 1989 (Pisarski 1992). In fact, carpooling was reported as a common practice among employed low-income people in a study in South Central Los Angeles where a quarter of lower-income workers carpooled, while one in five took the bus (Environmental Defense Fund 1998). In concurrence with this, based on the survey data collected in the Louisiana cities of Monrow, Ruston, and Grambling, Nwokolo (1990) found that low-income people were much more willing to participate in a carpool or vanpool program and use park-and-ride facilities for the program than were high-income people.

Table 5. Vehicle Availability by Income Group, 1995

Income	All Income groups	Low-Income Group	Other (Not Low-Income Group)	Low-Income Single Parents
Average Household Size	2.58	2.73	2.57	3.28
Average Number of Vehicles	1.78	1.16	1.89	0.72
Average Vehicle Age	8.3	10.9	8.1	10.8
Vehicles Per Adult	0.98	0.66	1.09	0.72
% of Households without Vehicles	8%	26%	4%	36%

Source: Murakami and Young (1997), table 4, based on 1995 NPTS.

Millar et al. (1986) also found that minority workers were significantly more likely to rely on ridesharing and public transportation. Among African-American workers, ridesharing appeared to substitute for public transportation as SMSA geographic size declined. However, it is not clear whether the tendency was due to race or their greater levels of poverty. Although carpool and vanpool appear to be feasible commuting modes for low-income people, Reichert (1998) noted constraints of vanpooling in schedule flexibility and demand responsiveness. These constraints make vanpooling problematic in serving the transportation needs of welfare recipients and low-income workers.

(3) Higher Likelihood to Walk

Murakami and Young (1997) noted that low-income households were much more likely to walk to work since 6% of their work trips were made by walking compared with 3% for other income groups in 1995 NPTS data. Similarly, they have a greater propensity to walk for family and personal business and for social/recreational trips. Walking accounts for 13% of social and recreational trips and 9% of family and personal business for low-income households, nearly twice as much as other-income households, which make only 7% of social and recreational trips and 4% of family and personal business trips by walking. Other data also confirms this greater tendency to walk among the low-income population. Lave and Crepeau (1995) showed that from the 1990 NPTS, persons in households without vehicles made 37% of their total trips by private vehicles, 37% by walking, and 23% by public transportation.

(4) Dependence on Buses

Taylor and Sen (1976) showed that low-income people's travel was primarily a function of where and when buses traveled and that their mobility was restricted by their dependence upon public mass transit. This explained why the majority of the trips of low-income people surveyed in Syracuse, New York, in 1974 occurred between 10 a.m. and 5 p.m., with a peak travel time from 10:00 a.m. to 2:00 p.m.

A related finding by Altshuler et al. (1979) is that low-income travelers, mainly those with incomes less than $7,500, rely on buses or streetcars much more than people in other income groups. As shown in table 2, 12.2% of all trips made by households with incomes lower than $5,000 were by buses and streetcars, as opposed to 4.4% by all households. Not surprisingly, table 3 shows that there was a relatively higher use of public transportation by the lowest income groups, and a higher use of automobile and commuter rail by the highest income group. Unlike the Taylor and Sen study in Syracuse, New York, where buses are the only transit mode, Altshuler et al. (1979) were able to look at different transit modes using nationwide survey data. More specifically within the spectrum of different transit modes, table 3 shows that while low-income households accounted for 34.1% of bus and streetcar ridership, they accounted for only 14.9% of rail rapid transit ridership, and 0% of commuter rail ridership. In other words, different income groups compose the major patronage of different transit modes with the lowest-income group being the primary riders of buses and the highest-income groups being the primary riders of rail rapid transit (Altshuler et al. 1979). Both of these studies in the late 1970s confirmed that low-income people constitute the main patronage of buses. Differentiating main patronage for each mode within the spectrum of all transit modes has major policy implications for transit subsidy distribution. Anderson (1989) noted that cities constructing rail systems often neglect their bus services, which low-income people use the most. Commuter rail serves primarily suburban travelers for inbound commutes. It does not serve low-income people so well. Outward-bound, low-income people need flexible forms of reverse commuting to reach outlying jobs. Wallace (1996) also noted similar equality issues in public-transit-subsidy distribution. While paratransit presents a solution to suburban mobility, it primarily serves elderly and disabled populations. He suggests more resources be diverted to support the use of paratransit for reverse commutes or direct access to outlying jobs for low-income people.

(5) Taxi as a Popular Mode

Table 3 also shows that the two lowest-income groups contribute to most of the taxi ridership. Only bus and streetcar riders have a lower income profile than taxi riders. In fact, Allred et al. (1978) noted that low-income people were frequent taxi riders because they are less likely to own a car. Taxis appear to be chosen over conventional transit by low-income people because they provide greater service flexibility, convenience, package space, duration of service, and security. More specific reasons for the modal choices of low-income people are: (1) bus does not stop often enough, (2) bus takes too long, (3) it is troublesome to locate and interpret schedules and maps for semi-illiterate, low-income people, (4) packages are too hard to handle on bus, (5) It is difficult or too far to walk to bus stops, (6) it is unpleasant to wait at potentially unsafe street corners for bus service, or they had experienced unpleasant incidents while taking public transit. Low-income people in small- and medium-sized urban areas are found to depend more on the taxicab than those in larger urban areas (Allred et al. 1978). Edin and Lein (1997) also found that low-income single mothers in the same neighborhood hired a neighborhood taxi driver to pick up their children when they could not pick them up due to shift work hours.

(6) Summary

The data from 1970 to 1995 are consistent in showing that private vehicles are the primary mode used by low-income people. They travel slightly more frequently in private vehicles as drivers than as passengers. However, compared with higher-income groups, low-income people are more likely to travel as private-vehicle passengers because of lower car ownership and the greater number of children per household. The sum of the percentages of trips made in private vehicles by the lowest reported income group in 1990 was 70% compared with 85% in 1990. Public transportation use by the lowest income group in 1969 was 14.5% compared with 3.7% in 1990. A major difference is the 21.3% walk trips in 1990 compared with none in 1974

(walk was not a reported category.) Because of this and other definitional differences, the numbers are not strictly comparable. The overall trend over time shows that low-income people travel more and more by driving alone and less and less by transit, carpooling, and walking.

b. Reported Trip Purpose

Trip destinations of the respondents in Talyor and Sen survey (1976) were primarily in the center of the city of Syracuse (Central Business District or CBD), in outlying areas where services were concentrated, and in areas where a large number of medical services were found. In addition, the majority of the trips were single-purpose, and most could be classified as shopping or social and recreational. Less than one-tenth were work-related trips. Buses were reported to be inconvenient for traveling to places of entertainment and grocery shopping, but convenient for shopping for goods other than groceries or when going to work and medical services. Scheduling and routing were identified as major problems associated with the restrictions on mobility of low-income people without automobiles.

Appendices G and H report data on person trips by all income groups. For the lowest income group, these data are summarized in appendix I. NPTS data that are reported in appendix I provide insights into most frequent trip purposes for low-income people in terms of person miles of travel, average person trips, and trip length. Appendix I reports the percentage of person miles of all travel by trip purpose and household income less than $10,000 based on 1983 and 1990 NPTS data. Appendix I summarizes average daily person travel, and person trip length by household and trip purpose based on 1990 NPTS data.

Appendix I shows that the group with incomes less than $10,000 makes almost four times more average daily trips for family and personal business than for earning a living, and more than twice as many average daily trips for social and recreational purposes than for earning a living. The group makes as many average daily trips for family and personal business and for social and recreational purposes as other income groups, while only half as many trips for earning a living. With regard to average daily person miles of travel, the group with income less than $10,000 travel twice as far for either family and personal business or social and recreational purposes as for earning a living. However, for the group, the work-trip length is much longer than that of a trip related to family and personal business or social and recreational purposes. Although the work trip lengths of other income groups are longer than those of the lowest income group, their trip lengths related to social and recreational purposes are even longer than those of their work trips.

The data in appendix I corroborate Taylor and Sen's conclusion on the trip purposes of low-income population. The major trip purposes for the group with an income less than $10,000 are family and personal business and social and recreational. Only a tenth of their daily trips are work related compared with a fifth for the next higher income group and a quarter for the highest income group. About a fifth of person miles of travel of the lowest income group are work related because of the longer length of work trips.

A 1976 study shows that most low-income people's trips were classified as shopping or social and recreational. Less than one-tenth were work-related trips. 1983 and 1990 NPTS data show that among the lowest-income group, work-related miles of travel increased from 15.5% in 1983 to 19.2% in 1990. Family and personal business miles of travel increased from 28.8% in 1983 to 38.3% while social and recreational miles of travel decreased from 44.1% in 1983 to 31.9% in 1990. In terms of average daily person trips, 1990 NPTS data show that 1.1 out of 2.6 trips are family and personal business related, 0.7 out of 2.6 trips are social and recreational ones, and only 0.3 out of 2.6 trips, about a ninth, are work-related. The daily trips made by low-income

people tend to be predominantly shopping or family and personal business related as well as social and recreational. Work-related trips increased from a tenth to a ninth from 1976 to 1990. The data are not directly comparable because the 1976 study was a local survey, while NPTS provides national data.

3. Emerging transportation needs of the low-income population

As noted above, welfare reform in 1996 has surfaced transportation requirements related to employment. Accordingly, several researchers are addressing the increase in transportation needs among the low-income population in that context (Rich and Coughlin 1998). O'Regan and Quigley (1998) assert that auto ownership is an important prerequisite for welfare recipients to participate in and complete job-training programs, and ultimately keep a job. Rich and Coughlin (1998) have also examined the role of transportation in helping the low-income population retain their jobs and achieve long-term economic independence. The transportation needs of welfare mothers would be much greater once they are working (Lacombe 1998, Lacombe and Lyons 1998). This is because of the need to make intermediate stops during the work commute to meet childcare and household responsibilities. These stops need to be made while commuting to the outer suburbs of metropolitan areas where entry-level jobs were located. Edin and Lein (1997) have shown that low-income employed mothers spent more than twice as much time on transportation by any modes that were affordable and accessible for them to complete all trip purposes as welfare-reliant mothers who were unemployed. A survey performed by the United States Conference of Mayors in November 1997 concluded five major transportation barriers to welfare-to-work transition. These barriers are (1) inadequate local bus schedules; (2) affordability of bus passes; (3) lack of public transportation routes to the main industrial centers; (4) long commutes; and (5) safety issues around bus stops and other areas (Kaplan 1998a). The Environmental Defense Fund (1998) pointed out the importance of conducting further studies on how welfare reform affects the transportation needs of the low-income population and transportation barriers in the welfare-to-work transition.

Lacombe (1998) looked at the transportation needs of low-income employed single mothers as a way to understand the emerging transportation needs of the low-income population. This is mainly because 90% of the welfare recipients, who are single mothers, will soon be required to be employed and face similar situations.

Travel patterns of single mothers appear to be different from those of men and of married parents. Several studies have pointed out that distinctive differences exist between the travel patterns of women and men (Wachs 1987; Rosenbloom 1988b, 1995; Rosenbloom and Burns 1993, 1994) and those of single mothers and married mothers (Cook and Rudd 1984, Johnston-Anunonwo 1989, Rosenbloom 1995). Transportation needs among low-income people differ due to factors such as gender and employment status. These are discussed below.

a. Gender-Related Needs

(1) Impact of employment status

Rosenbloom (1995) has concluded that employed women overall have different travel patterns and needs than employed men or unemployed women. The 1990 NPTS shows that employed women, 16 through 64 years old, in urban areas took 3.8 person trips per day, 12% more than unemployed urban women. On average, employed men made 19% more trips a day than unemployed men, while employed women took 33% more trips than unemployed women. Some researchers concluded that employment status has greater impact on the travel burden of

women than men because women retain more household responsibilities than men do. (Rosenbloom 1995, McKnight 1994, Lacombe 1998).

(2) Automobile dependence

The dependence of employed women, especially employed mothers, on automobiles has been interpreted as a result of their need to "trip chain" or link work commute with trips to school, day care centers, and other services (McKnight 1994). In fact, automobiles are considered the best and perhaps the only way to balance the childcare and domestic responsibilities they retain when entering the paid labor force (Rosenbloom 1995).

(3) Safety concerns

Several researchers have pointed out that travel safety of female drivers has become an issue over the last twenty years due to the changing role of women (Haapaniemi 1996a, Fredman 1994, Waller 1998). Fullerton (1989) predicted that women would account for 47% of the total labor force in the year 2000. He also noted that fewer women were in the work force in 1960, but now most women, about 60% by 1990, and even those with young children, are employed. Being in the work force allows women to have greater control over resources, resulting in higher car-purchasing power. Women are now purchasing about half of the new vehicles sold (Belton 1992).

A National Highway Traffic Safety Administration (NHTSA) study conducted by Cerrelli (1994) revealed an increase of 62.4% in women's highway death toll between 1975 and 1990. This increase may stem from a 12% increase in the number of licensed female drivers and a 23.7% increase in their mean annual travel, as well as an 18.2% relative increase in female drivers' risk of being in a fatal, single-vehicle crash. According to the United States Department of Transportation (1998), between 1975 and 1997, the number of male drivers in fatal crashes dropped from 45,084 to 27,658, a drop of 69% while women drivers' fatal crashes increased from 9,356 to 14,068, an increase of 50%. Although it is generally reported that women have shorter work commutes in terms of distance, they have longer trips in terms of time (Haapaniemi 1996b). These longer-time commutes are due to household-chores-related trips included in their work commutes (Mensah 1995). Other factors contributing to higher death rates involve children, alcohol, and lower crashworthiness of cars they tend to drive because of their lower salaries (Haapaniemi 1996b, Fredman 1994, Waller 1998).

(4) Impact of having children and household responsibilities

Researchers confirmed that having children and household responsibilities has greater impacts on women's commuting patterns and modal choice than on men's. Rosenbloom (1987 and 1994) has studied the impact of growing children on the travel patterns of their parents and found that having children had far more impact on employed mothers than on comparable employed fathers. Women with children were more likely to drive to work at all income levels than comparable men and other women. Women with younger and more children have a higher tendency to drive to work alone than those with older and fewer children. A recent *Women and Environments* article (1988) noted that a 1983 study of the attitudes of solo drivers, funded by the Urban Mass Transportation Administration, found that 39% of respondents considered childcare a major explanation of their solo driving because parents must have their cars to respond to a childcare emergency. The California Department of Transportation (Caltrans) also conducted a survey of childcare centers and participating parents. It found that personal vehicles are the predominant modes used and mothers have the primary responsibility for taking their children to childcare services. Rutherford and Wekerle (1988) also pointed out that

the age and number of children in a household affect not only the chance of a women entering paid employment, and whether she works part-time or full-time, but also the time and money she can spend on the journey to work. Several researchers (e.g., Mensah 1995, Turner and Niemeier 1997) also maintain that women tend to have shorter work trips and higher participation in part-time jobs than men because of their greater household responsibility. More women than men do not have enough time for job search activities. Women are less prepared than men to accept job offers in all parts of a region. Mensah (1995) found this to be true also for the low-income population and concluded that females' employment problems are more explicable in terms of their role as mothers and homemakers.

(5) Impacts of transportation-demand management programs

From her case study in the San Francisco, California, Bay area, Perez-Cerezo (1986) noted the different impact travel-demand management (TDM) programs might have on different groups of women. For women who make a simple commute trip both to and from work, shifting to a carpool might constitute a benefit from travel cost savings. However, for those who perform trip chains on the way to or from work for running errands and escorting children to and from school, it is impossible to shift to carpools unless some other arrangements are made. These changes are, for instance, more flexibility in their work starting time, sharing household responsibility with other adults, and providing safe pedestrian routes for children to walk to school. Rosenbloom and Burns (1993, 1994) specifically pointed out the negative impact that TDM programs might have on women with children. The negative impact stems from the fact that mothers are the least able to make drastic changes in their daily activities and use modes other than automobiles, and might be the most influenced by employer sanctions and financial penalties.

Women's role as mothers and homemakers is the consistent theme behind any gender difference in transportation needs and travel behaviors in the literature reviewed (Wachs 1987). In fact, Rosenbloom and Burns (1993, 1994) concluded that neither transportation policies nor income-enhancement mechanisms alone would fully address the real problems facing mothers in the paid-labor force. She noted that domestic responsibilities are a big determinant of a mother's travel behavior and suggested the development of strategies to alleviate the domestic responsibilities of all women and to which women could be more responsive.

(6) Single parenthood effect

Single mothers have been shown to make more trips than nonsingle mothers when income level or the availability of transportation resources were controlled (Kostyniuk et al. 1989, Rosenbloom 1995). The higher trip rates have been interpreted to be the result of the fact that single mothers make more "trip chains" then nonsingle mothers, due to the absence of the other adults in their household to share household and childcare tasks. Perez-Cerezo (1986) has found that the higher trip rates were due to single mothers having complete responsibility for escorting the children to and from childcare or school; married women share this task with their husbands. Rosenbloom (1989) has also pointed out that single mothers often add a shopping trip to the work-childcare or school-trip chain, and they can not afford to make as many discretionary trips as nonsingle mothers because most of their time is consumed performing household tasks. Kostyniuk et al. (1989) has also noted that single mothers make many more shopping trips and fewer social and recreational trips than nonsingle mothers. When employment status is considered, with no difference in shopping trip rates among employed and unemployed single mothers with driver's licenses, employed single mothers made more social and recreation trips than did unemployed single mothers. In general, single mothers make more trips and trip chains than nonsingle mothers.

Some aspects of the influence of single parenthood on the journey to work are still not clear. The effect of single parenthood is not often sorted out from the effect of income. Although Michelson (1983) found that employed single mothers had greater access to a car and longer work trips than nonsingle mothers, it is expected that, due to the frequent occurrences of limited financial resources and access to private automobiles, single mothers are more likely than nonsingle mothers to reside within metropolitan areas where accessibility to jobs and services (including public transit) is high. They were also expected to drive less and to use public transit more because of their lower likelihood to own cars. It is also expected that they work closer to home due to additional time and energy pressures that single parenthood demands (Kostyniuk et al. 1989). Rutherford and Wekerle (1989) also found that single mothers spend more time in their journey to work than either nonsingle mothers or men because of their dependence on transit and because they are likely not to own a car. However, they pointed out the trend of the growth of single-parent households living in the suburbs and their higher likelihood to work in the CBD or another region of the metropolitan area than in the suburbs. Johnston-Anumonwo (1989) has found the mixed result that single mothers, as expected, had lower access to private automobiles, but, contrary to expectations, they tended to have longer work trips than nonsingle mothers even though they were as likely as nonsingle mothers to use a car. Although single mothers were less likely to have cars in the household, they relied on an automobile for the work trips as much as married mothers did despite their lower financial standing (Johnston-Anumonwo 1989). Rosenbloom (1995) has attempted to separate income effect from single-parenthood effect. Although she has shown that low-income single and married mothers often took more trips and longer trips than women with considerably higher incomes, she has argued that certain differences in the travel pattern of single mothers from that of married parents of either gender were not influenced by simple economic variables. Children of moderate-income single mothers were more vulnerable than those of married couples, because they might be forced to make dangerous or dysfunctional travel choices due to a lack of adult companions. Similarly, single mothers who usually do not have other adults to share responsibilities are sometimes at the mercy of transit routing and scheduling when emergencies such as picking up a sick child from school occur (Reichert 1998).

b. Job-Related Needs

(1) Flexible schedule

Transit schedules are inadequate for low-income, transit-dependent workers because many of the entry-level jobs they qualify for require weekend or night-shift work. (Orski 1998, Reichert 1998).

(2) Emergency Services

Welfare recipients may need continued mentoring or assistance even after basic transportation solutions are put into place. When cars break down, a bus is missed, or an emergency arises with a child, a recipient may need help in funding immediate transportation. It is possible that a missed day of work can result in the loss of a job. In a focus group with a low-income, Medicaid-eligible population, it was found that the most popular features of paratransit service are personal attention and door-to-door service, while needed service improvements are "less notice for a ride" and on-demand service (especially for emergencies) (Freund and McKnight 1997).

(3) Personal Security

Personal security was one of the factors affecting low-income people's preference of taxi over bus as reported earlier in the section of modal choices. Vantuono (1997) pointed out that security is just as important as accessibility and on-time performance for transit passengers. Concerns about personal security also impact the travel patterns of women, especially when they need to travel during off-peak hours. Frank and Paxson (1989) concluded that women's mobility is restricted because they avoid making trips alone during off-peak hours due to their fear of being victimized. However, low-income people, who are predominately women, are often forced to make trips during off-peak hours because most entry-level jobs they are qualified for involve shift hours at nights or during weekends. In fact, high levels of perceived insecurity by women have been discussed, particularly for walking at night, in parks and subways, and when waiting for public transport services in isolated areas during off-peak hours (Lynch and Atkins 1988). Pearlstein and Wachs (1982) also note that captive riders of transit, the carless poor, elderly, and minority segments of society, perceive the highest levels of crime. Affluent Whites consider crime to be a reason for not taking public transit. Trench et al. (1992) have pointed out that the places causing most personal-security concerns were lonely bus stops, unstaffed stations, pedestrian subways, multistory car parks, badly lit quiet streets, and dark corners and hiding places in housing estates, almost all of which were transportation-related. Personal security is also a concern for car owners when they have to seek help in the case of breakdown on lonely streets or in multistory car parks at night (Trench et al. 1992). In addition, the functional separation of land uses in postwar planning in both Great Britain and the United States has resulted in deserted city centers after dark. However, a significant number of women have to be in city centers after dark as a condition of their employment. This is especially true for female cleaners, female shop assistants, secretaries, and shoppers (Oc 1991). Transit crime has been found to be a nationwide phenomenon, and the seriousness or frequency with which offenses are committed can not be ignored (Southeast Michigan Council of Governments 1981). However, crime prevention has not been a traditional function of the safety oversight agencies of most transit agencies and has not yet been addressed by them (United States Department of Transportation 1991).

(4) Higher mobility

Spatial mismatch (decentralization of worksites and housing (Lacombe 1998)) and the lack of automobile ownership are thought to be the major barriers to welfare-to-work transition and long-term economic sufficiency of low-income people. While three-quarters of welfare recipients live in central cities or rural areas, two-thirds of all new jobs in the nation have sprouted in the suburbs (Environmental Defense Fund 1998; Stanfield 1996). People in inner cities or rural areas need to reach suburban jobs despite the low rate of car ownership among the low-income population, particularly welfare recipients (Environmental Defense Fund 1998). Although transit is available, sometimes it is not a feasible solution for low-income people because it cannot take them everywhere they want to go, and it takes an unreasonable amount of time to get there due to the several transfers involved (Reichert 1998). A survey performed by the United States Conference of Mayors in November 1997 has also identified long commutes and lack of public transportation routes to main industrial centers as two of the major transportation barriers to the welfare-to-work transition (Kaplan 1998a). Orski (1998) also maintains that the long and complicated commutes of welfare recipients are attributed to the suburban locations of entry-level jobs for which they qualify.

Major factors influencing trip length are found to be income, occupational status, residential/workplace location, access to and use of an automobile, gender, race, and household characteristics (Cubukgil and Miller 1982; Fagnani 1987; Johnston-Anumonwo 1988,

1989; Rutherford and Wekerle1989; Kostyniuk et al. 1989; Rosenbloom 1989; Millar et al. 1986; Mensah 1995). Residential and workplace locations have been discussed as they relate to spatial mismatch by several of the authors noted above. Taylor and Ong (1998) define the term "automobile mismatch" as the condition of having less access to and use of automobiles, resulting in longer commute time among the low-income population. The issues evolving around the two factors will thus be referred to as spatial mismatch and automobile mismatch later in this report. The influence of gender, household characteristics, income, and work status has been mentioned earlier in this section. It is still not clear whether income effect, spatial mismatch, or automobile mismatch is predominant in limiting the ability of single mothers and low-income people to access jobs. Following are different explanations for longer commute distances and time among low-income workers with regard to access to and use of automobiles, residential/workplace location, and race.

(a) Automobile Mismatch

Single mothers have the lowest rate of car ownership, although a large majority are licensed to drive (Rutherford and Wekerle 1989, Rosenbloom 1989). Single mothers have the highest level of transit use, and spend more time than any other group in their journey-to-work (Rutherford and Wekerle 1989, Rosenbloom 1989). Several researchers reported that cars hold the key to making inner city job seekers more independent (Orski 1998; Blumenberg and Ong 1997; Wachs and Taylor 1997; Ong 1996) and to helping them juggle household and work responsibilities (McKnight 1994; Rosenbloom 1995). Taylor and Ong (1998) concluded, based on the metropolitan samples of the American Housing Survey in 1977-78 and 1985, that the mismatch of commute mode rather than spatial mismatch is what accounts for any differences in employment and income between White and minority workers. Wachs and Taylor (1997) also argue that automobile mismatch is the issue to tackle before spatial mismatch. First, they maintain that urban highway and transit systems were built intentionally to economically segregate metropolitan areas and to encourage middle- and upper-class suburbanization. Second, while a large proportion of transit resources were put into new rail lines that best serve car-owning suburban constituencies, bus fares were raised, and inner-city bus services decreased. Therefore, it is unreasonable to expect transit to be the answer to welfare reform in a society more and more dependent on automobiles. Cars hold the keys to the success of welfare reform.

(b) Spatial Mismatch

Lacombe (1998) has concluded that a primary reason for the longer trips that low-income single mothers have was a "spatial mismatch" between where they lived and where they were employed. Moreover, the trend of decentralization of housing and employment sites over the last twenty years radically changed the commuting patterns of all workers and had much greater impact on the low-income workers (O'Regan and Quigley 1998, Bogren 1996). Specifically, an increase has been found in the following commuting patterns: from suburban residences to suburban work-sites (from disperse origins to dispersed destinations) or from central city residences to suburban work-sites (reverse commutes to the suburbs). Low-income workers are more likely than other workers to commute between city homes and city jobs. They are also more likely to commute within suburbs and to commute from central city to suburbs and within suburbs. Although commute distances typically increase with income, low-income workers commute about eight minutes longer each day than other workers. Blumenberg and Ong (1997) point out that low-income workers cannot afford to work far from home since employers usually do not compensate welfare recipients for long-distance commutes. Long commutes may discourage employment and result in higher turnover rates and lower net earnings because

they reduce the net wages of low-wage workers by both out-of-pocket costs and opportunity costs.

Single mothers are found to be more likely to have centralized residential locations than nonsingle mothers. Single mothers tend to rent more, despite their greater likelihood to be full-time workers, than nonsingle mothers. Single mothers work disproportionately in service occupations, but their mean annual salary is only minimally and insignificantly higher than that of married mothers who work more in sales and clerical positions (Johnston-Anumonwo 1989). Income effect appears to limit the job and housing mobility of single mothers, compounded by spatial mismatch between affordable housing and entry-level jobs (Bogren 1998).
In terms of housing mobility, Cook and Rudd (1984) pointed out that low-income and discrimination, both in obtaining mortgage credit and in securing rental housing, influenced the residential locations of female householders, resulting in the concentration of female householders closer to central business districts. The locational process is further compounded by racial discrimination for minority women (Cook and Rudd 1984, Giluliano and Small 1993). As for job mobility, Cervero et al. (1995) noted that residents of low-income, inner-city neighborhoods faced the greatest occupational mismatch, defined as the inconsistency between residents' employment capabilities and labor-force occupational requirements at workplaces. Racial discrimination was a more serious obstacle to employment than job accessibility for minority individuals, in terms of the opportunities to efficiently reach employers (Cervero et al. 1995, Giluliano and Small 1993). Several researchers (Hanson and Pratt 1988; Rutherford and Wekerle 1988; Johnston-Anumonwo 1988, Villeneuve and Rose 1988) also maintained that a gender division of the labor market appeared to better explain gender differences in journey-to-work patterns than a household responsibility hypothesis. Giluliano (1988) pointed out that the spatial constraint from occupational sex segregation had greater impact on low-income women than most female workers because low-income women tend to be more transit-dependent, thus more mobility limited.

(c) Racial Variations in Commuting

Millar et al. (1986) have found that when income and residence location were controlled, African Americans, especially those in SMSAs, have significantly longer work trips (in terms of mean travel times). Among central city residents, only at the highest income level does the mean travel time of African Americans approximately equal that of White workers.

Orski (1998), Lacombe (1998), and Lacombe and Lyons (1998) report on how spatial mismatch poses mobility challenges for welfare recipients to get to work. Boston welfare recipients, even with a relatively sound mass-transit system serving downtown, face tremendous mobility problems originating from spatial mismatch between where they live and where they work and their dependence on transit. These problems include lack of transit service in the suburbs, gaps in existing service, long travel times, numerous transfers, and inadequate schedules.

Acquisition of automobiles seems to be an important solution in meeting the welfare challenge. In fact, inadequate funds limit the job and housing-location flexibility of low-income, employed, single mothers. This inadequacy also limits their mobility resources such as automobiles that are necessary to deal with the complexity of the travel patterns of single mothers. Moderate-income, employed, single mothers who can afford automobiles use them to meet these needs (Rosenbloom 1995). Lending support to this point, Taylor and Ong (1993, 1998) and Shen (1998) concluded the "automobile mismatch" of White and minority or low-income workers to be a much more important factor in explaining racial/ethnic variations in commuting than a spatial mismatch between minority or low-income workers and suburban employment. Similarly, car ownership has been considered to be a significant factor in helping welfare recipients find

employment and achieve economic independence (Blumenberg and Ong 1997; Orski 1998; O'Regan and Quigley 1998; Ong 1996). A survey of more than 1,000 female heads of households receiving Aid to Families with Dependent Children in California revealed that those owning automobiles enjoyed a significant advantage in terms of higher employment rates and total earnings. This is because owning an automobile enabled them to conduct a geographically broader job search, to accept offers farther away from home, to improve work attendance, and to keep the burden of commuting under a reasonable level. Barriers to the acquisition of personal vehicles by low-income people also include strict car-insurance regulations and federal regulations that prohibit individuals from receiving benefits if they own cars valued at over $1,500 (Kaplan 1998b; Blumenburg and Ong 1997; O'Regan and Quigley 1998; Ong 1996).

c. Summary

Female-headed households have faced the fastest growth in poverty rate in the last two decades. They accounted for 90% of the welfare population in 1997. They are in need of efficient and affordable transportation to get to outlying entry-level jobs and to make shift-hour commutes. This entails greater risks in safety and personal security while traveling. Once they start to work, they have a greater travel burden than men and nonsingle mothers due to the absence of other adults to share household responsibilities and the greater number of children in these households. Despite the lower car ownership in low-income female-headed households, these women rely more on automobiles and are most likely to be impacted by transportation-demand management programs.

C. How the Transportation Needs of the Elderly Are Being Met

To overcome the difficulties in meeting the transportation needs of the elderly (dependence on the automobile, residency in suburban and rural areas, random travel patterns, inadequate traditional transit service, disabilities, and safety and security), strategies in use have emphasized the following objectives:

- Safer and easier use of public and private vehicles
- Improvement in physical and mental capability in operating personal vehicles, and
- Increased transportation alternatives to traditional fixed transit

The overall goal is to increase the mobility of the changing elderly population without compromising their safety. There are many solutions now being applied to meet such needs. Some include ITS technologies, and some do not. Listed below is a range on non-ITS solutions. Following that is a discussion of several solutions that include ITS technologies.

Non-ITS solutions include:

- identification and evaluation of elderly drivers;
- improving and increasing transportation alternatives such as: 1) community-based services; 2) route substitution; 3) vanpool promotion and leasing; 4) late-night, weekend, and low-density service; and 5) feeder services to fixed route transit (Rosenbloom and Lerner 1990);
- decreasing barriers to implementation via: stimulated demand (Rosenbloom and Lerner 1990); increased availability of resources to transit providers so that they do not see special

services as a burdensome cost (National Eldercare Institute on Transportation 1994a, p. 8); and a change in the perception of public transportation from a low-status act to a high-status one (Heckman 1997, p. 35);

- policies such as increasing funding for needed community transportation services; allowing flexibility in trip purposes; improving coordination among transit agencies, service providers, and government regulations so as to make service delivery more efficient and equitable (National Eldercare Institute Transportation 1994b).

ITS solutions presented here address personal-vehicle improvements and improvements for other non-personal transportation modes, such as transit.

1. Personal vehicle/driving solutions

A great deal has been written about the use of technology, including intelligent transportation systems, to improve the driving capability and safety of the elderly. Stamatiadis (1998) reviewed past and current practices in the United States with respect to addressing problems of older drivers within the ITS framework. Vercruyssen (1997, p.6) identified three categories of ITS activities for driving assistance: driver training, vehicle enhancement, and roadway environment improvements. Research and development in the field of human factors has yielded measures to accommodate physical- and health-related impediments to driving, such as poor vision, decreased cognitive performance, decreased physical fitness, and fatigue. These developments have prolonged the elderly's ability to drive and have made the task of driving easier for them, thus helping to maintain their mobility.

(1) Vision

The topic of improving vision and visibility under driving conditions has been well documented. In the 1960s, Burg identified a wide variety of visual skills that potentially relate to driving performance, showing static and dynamic visual acuity to have a statistically significant correlation with accident involvement. In 1977, Shinar showed that under low illumination, static acuity proved to be the best predictor of overall accident involvement. Much research, particularly by Reading in 1968, has also shown that dynamic acuity (the ability to distinguish detail in moving objects) also declines with age and shows a significant correlation with accidents as reported by Shinar (Transportation Research Board 1988, p. 55-57).

Mitchell (1997) identified vision-enhancing technologies of special use to the elderly and disabled. An example is an infrared camera that can display a picture on a video screen, allowing the driver to see beyond his headlights at night and through fog, glare, and other adverse conditions. Some of these concepts are:

- Vision Enhancement – Ultraviolet rays are used to illuminate the road without blinding other drivers; infrared illuminates the driving scene so that reflected infrared can be detected using a device similar to a camcorder. The resultant image is projected onto a heads-up display to coincide with the outside scene.

- In-Vehicle Signs – Content of a road sign is transmitted from the roadside to a vehicle, and a replica of the sign is displayed either on a screen or on the dashboard via a heads-up display.

- Obstacle Detection – Blind-spot detection detects objects close to a slow-moving vehicle, avoiding collisions with people or objects hidden by darkness or blind spots. Obstacle

detection detects vehicles in hazardous positions during merges onto highways or lane changes.

(2) Cognitive performance

In addition to vision, technology has been developed to offset decreasing cognitive performance (including Alzheimer's Disease and dementia). Older persons tend to process information and solve complex problems more slowly than younger ones (Braune et al. 1985, p. 266-330; Welford 1981, p. 97-109). Many elements of highway design and operation are based on the assumption that most individuals can perform the perception-reaction task at a given speed (Transportation Research Board 1988, p. 94). Route guidance, navigation systems, and information broadcast systems assist the elderly driver in decision making. Safety warning systems such as collision detection are intended to help prevent accidents. Information from these systems is displayed on a video screen. Mitchell (1997) suggests several concepts that are of special use to the elderly:

- Collision Warning – Covers rear-end collisions, lane keeping, lane changing, merging, conflicts at junctions, head-on conflicts, and warns drivers of potential collisions.

- Navigation/Route Guidance Systems – In-vehicle systems that advise the driver on the route from the vehicle's present position to a preprogrammed destination.

- Traffic Information – Systems that provide real-time measurements of speed on motorways and main roads for visual display in a vehicle.

(3) Physical fitness and fatigue

Another impairment of concern to elderly is physical fitness and fatigue. Fitness levels may decrease, and elderly drivers may be more prone to fatigue as general effects of aging begin. In 1997, Mitchell and Suen linked ITS equipment with impairments related to fitness and fatigue. They identified ITS equipment using driver condition monitoring and intelligent cruise control as solutions to these problems (Mitchell 1997, p. 67).

Table 6 has a listing of various impairments, such as vision, cognitive, and fitness and fatigue and the ITS equipment to accommodate them.

An emerging trend of the past 30 years is the increasing rate of licensed elderly drivers. By 2010, 90% of women and almost 100% of men over 65 will be licensed drivers (Rosenbloom 1994). To prepare for the future, greater emphasis has been placed on the identification and evaluation of elderly drivers potentially posing risk, and training to adapt to changes in driving ability.

2. Nonpersonal vehicle/nondriving solutions

In addition to using technology to improve driving capability, technology has also been used to improve traditional and nontraditional transit vehicles. The problems that plague an older person's ability to drive also affect his or her ability to ride public transit. Vision, hearing, cognitive performance, and physical-fitness problems contribute to the lack of desire, insecurity, and fear regarding the use of public transit. Technology allows the transit user to overcome health problems and preconceptions of transit and fully utilize the transportation available.

Table 6. Impairments, Problems, and ITS Equipment for Older Car Drivers

Impairment	Problems	ITS Equipment
Increased reaction time. Difficulty dividing attention between tasks.	Difficulty driving in unfamiliar or congested areas	Navigation/route guidance, traffic information, VMS – Variable Message Signs
Deteriorating vision, particularly at night.	Difficulty seeing pedestrians and other objects at night and reading signs	Night vision enhancement, in-vehicle signs
Difficulty judging speed and distance.	Failure to perceive conflicting vehicles, accidents at junctions	Blind spot/obstacle detection, automated lane changing and merging
More prone to fatigue.	Get tired on long journeys	Intelligent cruise control, automated lane changing and merging
General effects of aging.	Worries over inability to cope with a breakdown; worries about driving to unfamiliar places, at night and in heavy traffic	Emergency callout (Mayday), vehicle condition monitoring, ATIS-Advanced Traveler Information Systems
Some impairments vary in severity from day to day. Prone to tiredness.	Concern over fitness to drive	Driver condition monitoring

Source: Mitchell (1997), p. 67

ITS concepts developed for public transportation are helping to solve these problems (United States Department of Transportation 1995, p.8). En-route transit information provides real-time, accurate service information to travelers using public transportation after they begin their trips by means of audio announcements or electronic message signs inside a bus, for example. Public travel security creates a secure environment for elderly users by monitoring the environment in transit stations, parking lots, bus stops, and on board transit vehicles, and by providing emergency Mayday service and manual and automatic alarms. ITS technology is also used for personalized public transit, providing on-demand service for small flexibly routed vehicles, such as taxis and vans. This service expands coverage to lesser-populated locations at potentially lower costs with greater convenience than conventional transit.

Table 7 lists common impairments and problems experienced by the elderly using public buses that have been identified by Mitchell (1997). Impairments involving poor vision, poor hearing, unfamiliarity with an area, lack of manual dexterity, and sensitivity to cold weather have caused problems for the elderly and the disabled, but they can be compensated for by technology. Hand-held units, service displays at bus stops, telephone information services provide trip and pretrip planning information, potentially aiding decision making. Displays, talking signs and buses, audio announcements, and induction loops overcome vision and hearing problems. These technologies can be implemented into other vehicles – paratransit, taxis, trains, and subways.

D. Solutions to the Transportation Needs of the Low-Income Population

Most of the strategies (both implemented and suggested) designed to increase the mobility of the low-income population deal with one or more of the following transportation-limiting elements:

Table 7
Impairments, Problems, and ITS Equipment for Older and Less Able Bus Passengers

Impairment	Problems	ITS Equipment
Cannot stand for long, sensitive to cold	Unable to stand while waiting at bus stops	Display of waiting time at home, at bus stop on hand-held unit
Unfamiliar with area	Do not know bus service details	Telephone information service
Poor vision	Cannot read service number	Service display at bus stop, audio announcement by bus
Poor vision	Cannot see community bus in time to hail it	Hand-held device for communication between bus and passenger
Lack of manual dexterity, cannot do things quickly	Paying cash while boarding	Smart payment card
Poor vision, unfamiliar with area	Cannot identify destination stop	Display name of next stop in bus
Impaired hearing	Hearing announcements	Induction loop in bus allows users to hear audio announcements directly through a hearing aid without interference from background noise.
No vision	Finding bus stop, knowing which stop for which service	Talking signs, stops that announce services from them

Source: Mitchell (1997), p. 59

- Economic barriers
- Inadequate attributes of transit, and
- A dearth of car ownership

The lack of satisfactory transport precludes many low-income individuals, who reside primarily in inner cities, from obtaining the suburbanized jobs that pay higher wages for lower skills. This factor serves to exacerbate "spatial mismatch," and has been identified as a major barrier for many in the welfare-to-work transition (Wachs and Taylor 1997). To combat the problems listed above, several approaches have been devised including the application of both new technologies and new transportation policies. These approaches can be differentiated into two categories of ITS and non-ITS solutions. Although the strategies are dichotomous (ITS solutions are wholly technological, non-ITS are not), they have the same goals and often times work in concert to meet these objectives.

1. Non-ITS Solutions

Non-ITS solutions for the low-income population include:

- reducing economic barriers via user-side taxi subsidies (CTAA 1996) and transit benefit programs (Reichert 1998);
- nonpersonal vehicle-related strategies including:

- flexible-route transit in small vehicles via utilization of existing vehicles and community human capital (Kaplan 1998a; Reichert 1998; and Laube et al. 1997) and augmentation the eligible user groups and trip purposes for paratransit (Freund and McKnight 1997);

- provision of emergency services such as guaranteed or emergency rides (Reichert 1998) and the removal of transportation barriers (Reichert 1998);

- successful reverse commute subscription services including facilitated transfers (Rosenbloom 1992; Lister et al. 1995); reduced walking distance (Rosenbloom 1992; Environmental Defense Fund 1998); and direct access to employment complexes (Rosenbloom 1992; Community Transportation Association of America 1998; BRW, Inc. and Biko Associates 1997);

- increased competitiveness of transit through equitable road pricing (Environmental Defense Fund 1998); simplified fare payment (Schulman 1995; Bolton 1997; United States Department of Transportation 1997b); comprehensive service zones (United States Department of Transportation 1997b; BRW, Inc. and Biko Associates 1997; and CTAA 1998); service expansion (United States Department of Transportation 1999; Rideworks 1998); and pro-childcare transportation planning (*Women and Environment* 1988);

- ensuring the personal security of transit riders through door-to-door service for vulnerable groups (Trench et al. 1992); ladycabs (Trench 1991); and non-electronic surveillance (Balog et al. 1993; Francois 1991; Malcolm 1996; Trench 1991; Caylor 1998; Pearlstein and Wachs 1982; Benjamin et al. 1993; Ingalls et al. 1993).

- personal vehicle-related strategies such as:

  - higher vehicle disregards (tax deductions) that allow recipients to own a reliable car without being penalized (Ong 1996; Reichert 1998; O'Regan and Quigley 1998);

  - financial plans and special programs like low-interest loans that enable recipients to own their own cars ((Reichert 1998; O'Regan and Quigley 1998)[5];

  - car donation programs as a source of affordable and reliable vehicles (Reichert 1998); and

  - linking vocational educational initiatives with ownership programs (Reichert 1998).

2. ITS Solutions

ITS solutions for the low-income population can be categorized into four groupings: schedule flexibility and demand responsiveness, emergency services, improving transit competitiveness and personal security. These are discussed in turn.

a. Improvement in Schedule Flexibility and Demand-Responsiveness

[5] Low-interest loans to recipients can be used for any purpose needed to obtain or maintain employment. Most approved loan applicants used the funds to purchase vehicles or to make repairs to existing cars in Wisconsin's job-access-loan program and Minnesota's family-loan program.

As mentioned earlier, Reichert (1998) has noted constraints of vanpooling in schedule flexibility and demand responsiveness that make vanpooling problematic in meeting the transportation needs of welfare recipients. Users cannot make an advance reservation such as for a job interview or an additional shift for services that operate on fixed schedules and require advanced reservations. Work Way, administered by the Meriden Transit District in South Central Connecticut, provides demand responsive van service to provide curb-to-curb transportation for riders to obtain and retain jobs (Rideworks 1998). ITS technologies have been used to improve schedule flexibility and demand-responsiveness of transit systems and are discussed later in this section.

b. Provision of Emergency Services

Emergency police or medical assistance

Automatic Vehicle Location/Computer Aided Dispatch (AVL/CAD) is able to provide appropriate emergency service, either police or medical assistance, in significant incidents such as attempted robbery of the driver, a medical emergency involving a passenger, or an altercation among passengers. Some transit agencies have found a 40% reduction in the time required to respond to an incident when using AVL/CAD (Jones 1997, Schulman 1995, United States Department of Transportation 1997b). While in the past, only bus schedules could be used to locate a stranded bus, AVL can now pinpoint a bus location within 50 meters. The savings in response time could mean the difference between life and death for a traveler experiencing an emergency health problem (MacLennan 1996).

c. Improving Transit Competitiveness

(1) On-time performance improvement

Several technologies have been developed that can improve the on-time performance of public transportation. These include transit vehicle tracking, traffic signal preferential treatment systems, and adaptive signal timing. These allow buses or light-rail vehicles to receive prioritized signaling when necessary to maintain schedules (PB Farradyne Inc. 1997; Bolton 1997; Schulman 1995; United States Department of Transportation 1997b). AVL/CAD systems can keep track of all vehicle locations, thus allowing a dispatcher to manage the fleet more effectively in keeping buses on schedule. Jones (1997) has reported that AVL/CAD deployment has resulted in a 23% increase in on-time performance of one route in the Baltimore Mass Transit Administration (MTA) service area in 1991. Similarly, Reynolds (1995) has reported that adding the AVL feature to a radio system can improve transit vehicle on-time performance and schedule planning. AVL also permits improved real-time monitoring, which allows transit systems to respond to accidents and incidents in a proactive manner by rerouting and rescheduling, ensuring that connections with other bus routes or other modes of transportation are made with minimum delay time (Jones 1997, Turnbull 1991).

(2) Informed choice-making

Traveler information systems use interactive computer and communications technologies to provide real-time comprehensive transportation information. Three major user-service areas that allow travelers to make informed choices on travel are pretrip travel information, en-route transit information, and ridesharing and reservations (Fisher 1997).

Traveler information systems allow travelers to obtain pretrip information from home, work, or even a hotel room. They can obtain pretrip and alternative trip itinerary information directly over

the phone or through their computers linked to the central processing unit. In addition, they can also obtain information on bus and rail schedule status and highway traffic and incidents before deciding how to travel. During trips, en-route travel information can be provided at major boarding points and transfer points and in the vehicle. This service provides travelers with on-going transit and high-occupancy vehicle information such as travel conditions, transfer points, and schedule adherence. In addition, real-time information can be displayed at wayside kiosks and through variable message signs. In-vehicle, next-stop information can be provided on bus and rail vehicles through variable message signs and automated annunciation systems (Caskey and Heermann 1997; Schulman 1995; Fisher 1997). By providing travelers useful and desired transit information (e.g., real-time routes, schedules, fares, mode options, parking availability) conveniently through a variety of media, a traveler information system could increase their control over their trips (PB Farradyne Inc. 1997, Schulman 1995; Bolton 1997; United States Department of Transportation 1997b).

(3) Ride-share dispatch

Ride-share dispatch is designed to deal with all aspects of dispatching ride-share vehicles. Its major components are ride/passenger matching, reservations, and taxi coordination. Ride/passenger matching matches ride requests with available rides. A reservation service takes ride requests and enters them into the matching function. Taxi coordination communicates with taxi dispatchers to provide backup demand-responsive services (Caskey and Heermann 1997). Ride-sharing and reservation user service expands the market for carpools and vanpools by matching the preference of riders and drivers and providing a clearinghouse for financial transactions. This service can be used to further develop ridesharing as an alternative to single-occupant automobile travel, and also to provide transportation alternatives to special groups (Fisher 1997).

(4) Collision avoidance

On-vehicle, collision-avoidance devices are designed to reduce transit vehicle collision, improve safety, and reduce costs and insurance claims (PB Farradyne Inc. 1997).

(5) Route guidance systems

Clear directions from route-guidance systems can help transit vehicles or personal vehicles avoid routes having unpredictable travel times and congestion. The reduction in trip duration can increase the ability of travelers to make longer trips to work or leisure activities, thereby gaining more options and flexibility (Diebold Institute for Public Policy Studies 1995).

(6) Timed transfer

Within the 3,000 square mile SMART (Suburban Mobility Authority for Regional Transportation) service area (mainly the three counties of the Detroit Metropolitan area), theoretically, any paratransit customer service can travel anywhere. But in practice, most rides are within six miles. This is because a transfer is required for longer rides, and there is currently minimal customer transfer between SMART and other providers. The use of timed transfer technology can improve the existing scheduling algorithms to be able to take the schedule adherence of each vehicle into account. This will eliminate the wait time during transfer and walking time to the greatest extent between fixed route transit systems and paratransit systems, thus reducing total travel time and maximizing travelers' ability to make longer trips (Lister et al. 1995).

(7) Flexible reservation systems

The concept of flexible reservation systems encompasses reservation interfaces for clients wishing to use demand-responsive vehicle fleet and real-time schedule generation that develops new routing and scheduling directions for the demand-responsive vehicle fleet, in response to new ride requests (Caskey and Heermann 1997).

Usual trip scheduling involves a batch process prior to the day of operation. The process needs to take into account factors such as availability and capacity of vehicles, driver lunch breaks, driver shifts, client on-board time, client special needs, travel time of day, loading times, requested times, potential need to perform a client transfer between vehicles. The degree of flexibility in scheduling is also restricted by the amount of time required to gather client information and determine accurate distances between two locations. All this requires clients to make reservations in advance. SMART uses the QuoVadis software from UMA Systems, Inc. as its dispatch software because its user interface and remote dispatch capacities allow clients to use a data telephone line to access the central database where the essentials of the requested trip would be input. Scheduling and dispatching systems combined with automated vehicle location (AVL) make it more effective to serve as-soon-as-possible trips by matching the address of a call with the closest available vehicle and relaying instructions to the driver in the most efficient and timely manner (Lister et al. 1995). This flexibility enables passengers to make and change reservations from their homes based on real-time information regarding schedules, fares, modal options, and parking availability, and it enables them to reserve immediate rides to job interviews or for emergencies (Diebold Institute for Public Policy Studies, Inc. 1995, Lister et al. 1995).

(8) Demand-responsiveness improvement

Automated vehicle-location technology as well as automated scheduling-and-dispatch systems are also being implemented to provide more flexible and responsive transit services that may play a role in addressing job access needs (Laube et al. 1997).

Centralized reservation and scheduling systems enable the coordination of public and private transportation providers within a service area. As noted above, SMART has considered the installation of a computerized reservation system for paratransit to coordinate the 75 different paratransit providers in the SMART service area. The system can also provide a centralized scheduling system and schedule riders onto any paratransit service. In the Empowerment Zone[6] (EZ) Ride initiative under the Program of Economic Independence of MAC[7] (Metropolitan Affairs Coalition) in Southeast Michigan, an automated scheduling-and-dispatch system is used to coordinate the services of various independent agencies. This provides more convenient and efficient transportation for zone residents' travel to work or needed services (Laube et al. 1997). Detroit's Operation ABLE, which mainly serves job seekers over 45 years old, has developed an on-site computer terminal connection to SMART's scheduling and dispatch system. This allows agency officials to act as local travel agents by booking clients on paratransit buses and by securing schedule and route information for existing main bus routes (Kaplan 1998b; Lister et al.1995; CTAA 1999).

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[6] The city of Detroit is one of the urban areas nationawide originally designated as a Federal Empowerment Zone (Laube 1997). The Presidential Empowerment Initiative launched the Empowerment Zone and Enterprise Community Program in which the federal government offers a compact with communities and state and local governments. The federal government will waive burdensome regulations whenever possible, and work with them to make federal programs responsive to state or local plans if they design and drive the course for real change from economically distressed states (EZ/EC Program Offices, 1995).

[7] "The Metropolitan Affairs Coalition (MAC) is a regional leadership coalition of business, labor, and government through which the public and private sectors confront public-policy issues affecting the economic vitality of Southeast Michigan. The organization is funded by private contributions from business, industry, and labor. It is a problem-solving organization, not a service provider" (SEMCOG 1999).

d. Ensuring the Personal Security of Transit Riders

(1) Reduction in wait time

Several transit agencies indicated that their customers were afraid to wait at bus stops for uncertain periods (Jones 1997). The vulnerability of transit riders at a stop is decreased by knowing when a vehicle will arrive and the avoidance of long waits (City of Toronto Planning and Development Department and Wekerle 1992). Automatic vehicle location (AVL) systems can fine-tune bus schedules for better on-time performance, allowing travelers to time their arrival more accurately at bus stops. This decreases the length of time available to feel vulnerable to crime (MacLennan 1996). Existing pager technology can also be used to provide transit information, by means such as alerting a customer to the imminent arrival of a bus to minimize outdoor waiting time (Caskey and Heermann 1997).

(2) Surveillance

Electronic Surveillance

Electronic surveillance can include any of the following technologies: closed-circuit TV, partial police radio system, passenger alarms, video surveillance systems, silent alarms, automated vehicle location/computer-aided dispatch (AVL/CAD) systems, and security cameras. Both human and electronic surveillance has been applied to address personal security issues in transportation-linked spaces. Closed-circuit TVs, partial police radio systems, and passenger alarms have been used in Great Britain and found to be critical elements of transit crime prevention devises (Francois 1991; Balog et al. 1993). In fact, video surveillance systems and silent alarms of AVL/CAD systems help dispatchers to understand what happens on board transit vehicles. A driver can depress a covert alarm button causing lights on the dispatcher's control panel to flash immediately, taking priority over other activities. The dispatcher can activate a covert microphone on the bus and listen to what is happening. The dispatcher can then notify the appropriate emergency service to tell them the exact location of the bus emergency without passengers' knowing that help is on the way or that the driver has alerted anyone (Jones 1997; United States Department of Transportation 1997b). Video surveillance systems can also increase security in all kinds of transit facilities (United States Department of Transportation 1997). An example is the Los Angeles County Transportation Commission's Blue Line, which employs officers and farecheckers to patrol the line. It also installs security devices both inside its cars and in all stations to reduce the fear of crime (Bowen 1990). Security cameras have been widely installed in toll plazas, subway platforms, traffic lights, tunnels, bridges, and bus stations in New York (Halbfinger 1998).

IV. FINDINGS FROM FOCUS GROUPS AND INTERVIEWS

A. Background

Focus groups and interviews were conducted with elderly and low-income people and their service providers. These were done to identify the transportation needs of these two population groups and to obtain their suggestions on what type of transit service might best meet those needs. The focus groups and interviews were conducted in southeast Michigan. While there is no rail transit in southeast Michigan, there are transit authorities in the region that provide both fixed route and paratransit service, increasing the similarity of the transportation use in the region with that of other areas.

Data collected from these focus groups and interviews provide insight into the transportation needs of elderly and low-income people and provide the basis to formulate more comprehensive studies that would yield statistically significant results.

B. Interviews

Groups in society that are unable to meet their transportation needs were identified by reviewing economic and demographic trends and through discussions with individuals who are knowledgeable about such transportation needs. Discussions were also held with service providers at residential locations of elderly and low-income people. These locations represented the sites of potential focus groups for the study. Service providers at eight different locations were contacted by phone, and preliminary interviews using an interview guide were conducted. In-person interviews were subsequently conducted with service providers at four locations, and focus groups held at two of those.

C. Focus Groups

1. Method

Focus groups were conducted at two Ann Arbor, Michigan low-income, public-housing sites. They were held July 29 and December 17, 1998. After the participants were welcomed and introduced, they were asked to complete a questionnaire to obtain demographic data. This questionnaire is included as appendix J.

Next was a discussion on the adequacy of present travel means. Participants were asked to give reasons why some trips are inconvenient or unsatisfactory. The discussion revolved around destinations, modes, time of day, being with or without children, and other issues.

The groups then discussed future transportation needs. Participants were asked to think ten years from now and to articulate lifestyle and desires, their anticipated trip destinations, mode of travel, and trip purposes.

The discussion then focused on transportation options, specifically intelligent transportation system (ITS) options. ITS was defined, and selected innovative transportation methods were described to the participants. Participants were asked to think of other transportation options and why they do not consider certain modes of transportation to be options for them.

Finally, the participants completed a brief questionnaire asking for their present trip destinations and desired destinations that they are unable to travel to. Participants in the second focus group were asked to rank by consensus the five most important destinations and the seven

most important transportation attributes, and all participants were asked to offer any other thoughts, ideas, or suggestions they may have had. At the end of the focus groups, the participants were given cash compensation.

2. Participant descriptions

The first focus group was held in the community center of a public-housing site. Ten people participated, eight of whom completed the initial questionnaire. The eight participants who completed the questionnaire ranged in age from 23 to 44 with an average age of 35.25. Seven were African-American, and one was Caucasian. Three were married; three were single; and two were divorced. Six reported they had children, of whom the minimum number was four and the maximum was seven. Of the eight participants, seven were women, and one was a man. Five participants made less than $10,000 a year; only one reported an income greater than $30,000. Six reported having work experience, with the average number of years of experience 6.3. None of the participants held a college degree, and three reported not finishing high school. Of the eight, only one owned a car, and only three had a driver's license. Seven of the eight participants held jobs, most as hotel housekeepers and cashiers.

The second focus group was held in another low-income, public-housing site. Three women aged 25, 26, and 71 participated. The two participants in their mid-twenties were single, and the 71-year-old was married and caring for her disabled husband. The 26-year-old was Caucasian, while the other two were African-American. Each of the three reported having children, with the two African-American women having two and the Caucasian having one. All three had some college education. Of the three, only the 25-year-old earned more than $10,000 (she reported an income between $10,000 and $20,000). The two women in their mid-twenties reported 3 or 4 years' work experience, while the 71-year-old woman reported 12 years. The two younger women each owned an automobile, while the 71 year-old used bus transit services.

3. Focus group discussions

a. Adequacy of Present Means of Travel

After the participants completed the questionnaires, the group discussion concentrated on their present means of travel and the adequacy of those means. The participants of both focus groups were asked, "Why are some trips inconvenient or unsatisfactory?"

Various reasons were given by the focus group participants on the inconvenience of trips. The reasons ranged from lack of transit services to difficult drivers. One concern expressed by most in the group was the lack of public transportation service for mothers grocery shopping with children. Many mentioned the difficulty in carrying grocery bags in buses and the lack of help of taxi cab drivers in loading and unloading. Following are the characteristics of inconvenience of the public transportation services:

- Not on time; long wait
- Takes too long to get to a place
- Not enough hours of service, especially nights and weekends
- Taxi cabs are too expensive
- Bus stops are too far away from home
- Lack of safety and security
- No express services
- Lack of service to certain areas; not enough routes

- Limited number of passengers allowed in certain services (subsidized taxi for disabled people); difficult for single mom with five children
- Hard to understand schedules
- Some drivers are rude, impatient, and unhelpful (do not help loading/unloading groceries); feel unsafe because of the way taxi drivers look and drive
- Bus drivers do not always wait for passengers to sit down before starting to drive

b. Future Transportation Purposes and Destinations

The participants were next asked to identify future transportation destinations and purposes ten years into the future. Most responses can be categorized as shopping or social and recreational trips and are presented in those categories in table 8.

Table 8. Future Transportation Purposes and Destinations Reported in Focus Groups

Social and Recreational	**Family and Personal Business**
• entertainment (movies, theaters, night clubs) • vacations • library • park **Employment/Earning a Living** • work **Civic, Educational, and Religious** • schools • church	• children's sports • dentists • hospitals • shopping • grocery • visit family • daycare centers • court • paying bills • banks

Members of the second focus group also ranked their five most important destinations based on consensus. In order of importance they are: health care, daycare, employment, personal business (such as paying bills), and shopping.

The individuals of the second focus group had varying opinions on the different transportation purposes and destinations. One said education was her first priority. She also thought finding daycare was more important than employment, stating that she needed to find daycare before she could find work. Another, however, thought employment was more important than daycare because she could not pay for daycare unless she had a job. Another indicated that, of the top five ranked by consensus, only shopping and health care seemed important to her. When asked how they would travel to their desired destinations, the participants of both focus groups mentioned the following modes: car, bus, train, plane, bicycle, and walking.

c. Transportation Options

Following a discussion of what the participants thought would be their future transportation needs, the participants were asked to consider what new technologies might meet their needs. This discussion was introduced by a description of the following seven intelligent transportation system technologies:

Intelligent Transportation Systems - Apply advanced and emerging technologies in such fields as information processing, communications, vehicle control, and electronics in order to improve

the surface transportation system. Application of many of these technologies will be in the form of expanded or new transportation user services.

Personalized Public Transit - Small publicly or privately operated vehicles pick up passengers who have requested service and deliver them to their destinations. This service can provide almost door-to-door service, expanding transit coverage to lesser populated locations and neighborhoods.

En-Route Transit Information - Provides information to assist the traveler once public transportation travel begins. Real-time, accurate, transit-service information on-board the vehicle helps travelers make effective transfer decisions and itinerary modifications as needed while a trip is underway.

Public Travel Security - This service provides systems that monitor the environment in transit stations, parking lots, bus stops, and on-board transit vehicles, and generate alarms, either automatically or manually, when necessary. This improves security for both transit riders and operators. Transportation agencies and authorities can integrate this user service with other anticrime activities.

Ride-Matching/Sharing – This service provides real-time, ride-matching information and reservations to users in their homes, offices, or other locations, and assists transportation providers, as well as van/carpoolers, with vehicle assignments and scheduling. This will expand the market for ridesharing as an alternative to single-occupant vehicle travel and will provide for enhanced alternatives for special population groups, such as the elderly or handicapped.

Electronic Payment Cards – Electronic payment services will foster intermodal travel by providing a common electronic payment medium for transportation modes and functions, including tolls, transit fares, and parking. Such systems could be expanded to become truly multiuse, accommodating personal financial transactions that are made with today's credit and bankcards.

Car Navigation – This provides a suggested route to reach a specific destination. When fully deployed, route-guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route-guidance system will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route.

The group's reaction to the ITS concepts presented was mixed. Some saw potential benefits of the technology, while others remained hesitant. When asked for their thoughts and ideas, the following responses were given:

- They will help you get there on time (because of better service).
- Payment cards are bad because privacy, security, and identification are taken away for convenience.
- Ride matching requires that you have money on the day rides come by.
- How do they take children? Flexibility and roominess are needed in seats.
- New technology is more convenient for the government and compromises privacy; technology should help without compromise.

Privacy and security were the major concerns with regard to future technologies. During the discussion on technology, most participants seemed uninterested and may not have fully grasped the ITS and other technological concepts.

d. Ten Years into the Future

The participants were then asked to think of other transportation options and strategies, including modes and service concepts that would be useful ten years from now, as well as to consider why certain modes of existing transportation are not considered as options. The responses are listed in table 9.

Table 9. Future Transportation Options and Characteristics Suggested in Focus Groups

• Cable cars	• People movers/trolley cars
• Moving sidewalks	• Carpooling
• Affordable cars	• Affordable transportation
• Lower insurance costs	• Greater awareness of issues
• More options for the elderly	• Electric and solar cars
• Foldable/small portable transportation	• Better hours of service
• Anything that will take you anywhere on time and is affordable, efficient, clean, smells good, and is comfortable	

Some participants appeared to have difficulty in thinking of transportation options ten years into the future. The participants were primarily concerned with ways to make cars available to low-income people and welfare recipients. One participant talked about a car donation program, through which used car dealers and junkyards fix up low-maintenance cars for single parents on welfare. Another mentioned the police setting aside confiscated vehicles for auctions. However, one person thought that cheap, well-maintained used cars are not the ultimate solutions to their needs. She was very concerned about pollution from excessive automobile use.

Some focus group participants were positive about carpooling because of the networking opportunities and shared household responsibilities such as taking care of children or shopping. They were receptive to public vans and carpools organized by employers because they did not have to worry about being late for work. Once they were on the vehicle, they had no responsibility for being late. This was an important consideration regarding traffic congestion.

4. Trip purposes

After the discussion, the participants were walked through a final questionnaire that asked each participant to identify his/her usual and desired trip destinations, what new transportation services he/she thinks would help meet transportation needs, and any ideas, thoughts or suggestions relating to their transportation needs.

The most usual destinations for the group were work, school, doctors, and church. When asked to list destinations where they would like to go but are unable to travel to, they listed grocery stores, doctor's appointments, church during weekdays and Sundays, and visiting family within a 50-mile radius. The inability to travel to desired destinations may illustrate the inadequacy of their current transportation modes in providing trips to medical care and for longer inter-city and off-peak-hour trips. Local transportation service also appears to be inadequate in meeting basic needs such as grocery shopping.

5. Transportation attributes

The participants of the second focus group were asked to rank seven transportation attributes individually and then by consensus based on two scenarios. The first scenario had the automobile as their primary mode, and the second had public transit as their primary mode.

The following seven transportation attributes were used in the discussion and are defined below. The definitions in Rosenbloom and Fielding (1998) for travel time, convenience, user costs, and feasibility were borrowed and slightly modified here, and the study's authors defined safety, security, and reliability.

Safety - The ability of a transportation system to reduce its clients' chance of getting involved in accidents or crashes.

Security - The ability of a transportation system to reduce its clients' chance of being attacked during their travel which includes walking to parking, bus stops or subway stations, waiting for bus or subway, and in-car, in-bus, or in-subway time.

User Cost - Money spent on investment and maintenance of personal transportation means and out-of-pocket cost such as bus ticket, gas, and toll fee.

Reliability - The ability of a transportation system to meet its clients' expectations of when transportation means should be available to them and how much time it should take to transport them from a place to their destinations by certain means. Examples are absence of breakdowns, on time performance of buses and subways, and minimized impact of congestion on travel time.

Travel Time - Time spent on traveling from a place to your destinations including walking to or from bus stops, bus waiting time, on-bus time, or walking to or from parking and looking for parking.

Convenience - The easiness of transfer between different transportation means, the flexibility of a transportation system's schedule, and the ability of a transportation system to meet its clients' personal needs such as the need to travel with young children and heavy belongings.

Feasibility - The technical and financial capability of a transportation system to carry out services tailored to special situations and needs of its clients such as subscription services to large employers, guaranteed ride home during off-peak hours, childcare facilities and concierge services at transit station, or vehicles designed to make entering and exiting a vehicle easier.

Table 10 shows the ranking of the seven transportation attributes by the second focus group. From the rankings, different value is placed on each attribute based on transportation mode. For example, the group found security to be the most important transportation attribute for public transportation, but considered it to be only sixth for automobile.

Convenience and travel time were considered more important for automobiles than for public transit. The participants said that it was because public transit in general was not capable of providing satisfaction on convenience and travel time. Therefore, the results should be interpreted differently. Instead of being unimportant transportation attributes for public transit, travel time and convenience were the main reasons automobiles are preferred over public transit. While safety appears to be equally important for both automobiles and public transit, security was the most important attribute for public transit and very much less important for

Table 10. Consensus Ranking of Attributes in Order of Importance*

Primary mode: Automobile	Primary mode: Public Transit
1. Safety	1. Security
2. Reliability	2. Safety
3. Convenience	3. User Cost
4. User Cost	4. Reliability
5. Travel Time	5. Feasibility
6. Security	6. Convenience
7. Feasibility	7. Travel Time

* 1 being most important, 7 being the least

automobiles. Consistently, all of the participants agreed that reliability was more important than convenience for both cases. User cost was somewhat important for automobile while much more important for public transit. Feasibility seems to be more of an issue for public transit than for automobiles. One of the participants offered during the discussion of feasibility that her problems would all be solved if transit stations provided daycare and concierge services.

D. Summary of Findings From Focus Groups and Interviews

Transportation needs of the elderly that were identified in this study were from the literature and interviews with their service providers. Because these service providers represented only the nonmobile elderly, information on the elderly is not included in this section.

Low-income people who participated in the focus groups, most of whom travel by public transportation, indicated a range of problems with their current mode. These problems, primarily revolve around adequacy of service (scheduling, routing, convenience with children, and expense) of public transportation.

The most prevalent trip purposes currently are work, school, medical care, and church. Participants indicated they wished to be able to travel to the following destinations, but were unable to do so: grocery store, doctor appointments, weekday and weekend church, and visiting family and friends within a fifty-mile radius. Clearly, some participants were able to go to these places on occasion. One group ranked the importance of their trips in this order: health care, daycare, employment, personal business, and shopping.

Future desired trip destinations are the same as those of the present with the addition of social/recreational and additional family and personal business trips.

When presented with a variety of new technologies for future transportation, the focus group participants had mixed responses. While there was some positive response, concerns included timeliness, privacy, security, cash availability, child-friendliness, and convenience.

Most suggestions on options for future transportation focused on ownership of private vehicles and their affordability. Other suggestions included carpooling and modes such as cable cars, trolleys, and people movers. Characteristics of the modes include affordability, better hours of service, efficiency, cleanliness, and comfort.

When asked about the most important attributes of automobile transportation, the participants noted their first three were safety, reliability, and convenience; whereas for public transportation they would be security, safety, and cost.

V. ANALYSIS

Information collected in the literature search, the interviews, and the focus groups is integrated in this section. Presented here are trends of the characteristics of the elderly and low-income populations (Hu and Young 1999), and tables of a range of potential solutions to the transportation needs of the elderly and low-income populations along with the attributes of each solution that these two populations desire in their modes of transportation.

A. Trends

Historical and expected trends of the transportation-related characteristics of the elderly and low-income population are useful in attempting to understand emerging needs for nontraditional transit. From 1960 to 1994, the population of people over the age of 65 increased from 16.5 million to over 33 million. These numbers are expected to grow. Currently, one in eight Americans is over the age of 65, but by 2030 about one in five is expected to be elderly. The gap between the rich and the poor is expected to increase. While the poverty rate has remained relatively steady over the last decade (13.1% in 1989; 13.3% in 1997), the share of aggregate income for the top fifth of all families grew 47.2%, while the bottom fifth's share dropped 4.2% over the last 30 years (United States Bureau of the Census, 1998).

The daily person miles of travel (PMT) in the general population has increased by 49% from 1977 to 1995. During the same time period, the average daily number of person trips increased 47%. The elderly have followed this trend. From 1990 to 1995, the average daily PMT for people aged 65 and over increased from 18.4 to 24.4, and the average daily person trips increased from 2.49 to 3.43. From 1983 to 1990, the average annual miles traveled by those aged 65 and over rose from 4,457 to 5,600. Similarly, low-income people (less than $10,000 household annual income) increased their average daily number of person trips from 2.1 to 2.6 between 1983 and 1990. The average daily PMT for this group increased from 14.3 miles to 16.0 miles during the same period.

Over the last 50 years, the percentage of travel by private vehicle has increased enormously concurrent with a decrease in the use of public transportation. This has been consistent with an increase in ownership of personal vehicles. The trend has held for the elderly, with the percentage of trips by the elderly by public transportation decreasing from 2.6% to 1.8%, and the percentage of trips made by private vehicle increasing from 83.9% to 90.3% between 1983 and 1990. For the low-income population during the same period, the percentage of private vehicle trips increased from 68.9% to 70.0%, and the use of public transportation decreased from 4.3% to 3.7%. This trend is not expected to reverse because of the higher use of personal vehicles by this population group.

Geographic locations for residential and employment uses are pivotal in understanding transportation needs. The more densely settled an area, the more likely that transit options will be viable. Alternatively, the less densely settled an area, the greater the likelihood that people will rely on personal transportation. With the advent of the automobile, people became more able to reside in areas more distant from city centers. More recently, business locations have also moved to outlying areas. These trends have created more work-based travel and other travel that is not centered in downtown areas, but rather is suburb-to-suburb. As people have aged in place in suburban areas and are less able to drive, a need for other modes to meet their mobility needs is growing. In addition, the suburbanization of businesses has created reverse-commuting needs for low-income people who live in city centers. Both of these groups have emerging mobility needs that are not met by automobiles (one group cannot drive, and the other has lower rates of car ownership).

B. Potential Solutions

Tables 11 through 14 provide preliminary indications of how various potential ITS solutions would meet the transportation needs of the low-income and elderly populations for both personal and public transportation services. Potential solutions were identified through the literature search and the focus groups. In the cells of the tables are asterisks that indicate that the potential solution meets the transportation-related need indicated at the top of the column. For example, the asterisk in table 11 at the intersection of en-route driver information and convenience indicates that if a person had an electronic device that provided driving directions when en-route, the individual would be likely to find traveling more convenient. An attempt was made to place the columns in decreasing order of importance to the populations indicated. This ordering is not exact, but is based on the results of the focus groups and a consensus from the literature review. Thus, more asterisks in the earlier columns of a row indicate a higher value to the user of the potential solution.

Judging from the preliminary indications given by the tables, ITS technologies appear about equally beneficial to both the elderly and low-income populations whether applied to private or public transportation. This conclusion is reached if the attributes are not weighted (that is, independence is not counted as being preferable to minimal cost for an elderly individual). With regard to the implementation of ITS in personal vehicles, the proportion of desired attributes that the new technologies actually supply is similar for both populations, although some bundles are more beneficial to the populations than are others. For instance, with respect to ITS as it applies to private transportation, both low-income and elderly individuals, in accordance with their stated preferences, appear to realize the maximum benefit from the electronic payment "bundle." In the deployment of ITS in public transportation vehicles, the possible benefits accumulated by each group again are similar, with the travel demand management "bundle" yielding the maximum return to both populations.

In comparing between modes rather than between bundles, the elderly stand to gain more from ITS implementation in mass transit than in its application to private vehicles. Such a marked difference is not present for the low-income population, for the benefits they receive from ITS deployment in public and private vehicles seem about the same.

It should be noted that all of the above conclusions were reached according to the stated preferences developed through a literature search and, more specifically, focus group research. Consequently, these conclusions cannot be used for inference to the population as a whole.

Table 11. Personal Transportation Attributes Desired by Low-Income People and Potential ITS Solutions

Potential ITS Solutions	Personal Transportation Attributes Desired by Low-Income People					
	Safety	Reliability	Convenience	Minimal Cost	Travel Time	Security
Travel and Transportation Management						
En-route driver information			X		X	
Route guidance			X		X	X
Traveler services information			X		X	X
Traffic control	X				X	
Incident management	X				X	
Emissions testing and mitigation						
Travel Demand Management						
Ride matching and reservation			X	X		X
Demand management and operations	X					
Electronic Payment						
Electronic payment services	X		X		X	X
Emergency Management						
Emergency notification and personal security	X					
Advanced Vehicle Control Safety Systems						
Longitudinal collision avoidance	X					
Lateral collision avoidance	X					
Intersection collision avoidance	X					

Vision enhancement for crash avoidance	X					
Safety readiness	X					
Precrash restraint deployment	X					
Automated highway system	X				X	
Nonbundled Individual Solutions						
In-vehicle signs	X					
Obstacle detection	X			X		
Intelligent cruise control	X					
Variable message signs	X		X	X	X	
Driver condition monitoring	X					

Table 12. Personal Transportation Attributes Desired by Elderly People and Potential ITS Solutions

Potential ITS Solutions	Personal Transportation Attributes Desired by Elderly People						
	Independence	Safety	Security	Minimal Cost	Convenience/ Flexibility	Reliability	Travel Time
Travel and Transportation Management							
En-route driver information	X				X		X
Route guidance	X		X		X		X
Traveler services information	X		X		X		X
Traffic control		X					X
Incident management		X					X
Emissions testing and mitigation		X					
Travel Demand Management							
Ride matching and reservation	X			X			
Demand management and operations		X					X
Electronic Payment							
Electronic payment services		X			X		X
Emergency Management							
Emergency notification and personal security	X	X					
Advanced Vehicle Control Safety Systems							
Longitudinal collision avoidance		X					
Lateral collision avoidance		X					
Intersection collision avoidance		X					

Vision enhancement for crash avoidance	X	X					
Safety readiness		X					
Precrash restraint deployment		X					
Automated highway system		X					X
Nonbundled Individual Solutions							
In-vehicle signs	X	X					
Obstacle detection	X	X					
Intelligent cruise control		X					
Variable message signs	X	X					
Driver condition monitoring	X	X					

Table 13. Public Transportation Attributes Desired by Low-Income People and Potential ITS Solutions

Potential ITS Solutions	Public Transportation Attributes Desired by Low-Income People					
	Security	Safety	User Cost	Reliability	Convenience	Travel Time
Public Transportation Operations						
Public transportation management	X			X	X	X
En-route transit information	X				X	
Personalized public transit	X				X	X
Public travel security	X				X	
Travel Demand Management						
Pretrip travel information				X	X	X
Nonbundled Individual Solutions						
Smart payment card	X				X	X
Display of waiting time at home or bus stop	X				X	
Hand-held device for communication between bus and passenger	X				X	

Table 14. Public Transportation Attributes Desired by Elderly People and Potential ITS Solutions

Potential ITS Solutions	Public Transportation Attributes Desired by Elderly People						
	Independence	Safety	Security	User Cost	Reliability	Convenience/ Flexibility	Travel Time
Public Transportation Operations							
Public transportation management	X				X	X	X
En-route transit information	X					X	
Personalized public transit	X					X	X
Public travel security	X		X			X	
Travel Demand Management							
Pretrip travel information	X				X	X	X
Nonbundled Individual Solutions							
Smart payment card	X		X			X	X
Display of waiting time at home or bus stop	X		X			X	
Hand-held device for communication between bus and passenger	X		X			X	

VI. SUMMARY AND CONCLUSIONS

A. Overview

The purpose of this study was to perform a preliminary identification of the future transportation needs of various segments of society that will be unable to meet such needs through conventional private vehicles, but will likely require nontraditional transit services. To meet this purpose, segments of the population that will continue to increase in the next twenty years and will be unable to meet their transportation needs were identified. By reviewing economic and demographic trends and through discussions with knowledgeable people, the two groups identified were the elderly and those with low incomes. The emerging characteristics and transportation needs of these two groups were identified through a literature review, interviews with service providers, and focus groups in the southeastern Michigan area.

B. Observations

Social service providers for the elderly and low-income populations were identified and contacted. Identification of these people was not straightforward. Contacts were made via networking. Some service providers were extremely helpful; others were less so. The helpful ones spoke by telephone or met in person with project staff and shared a great deal of information. Topics discussed included scheduling, use of meeting facilities, and abilities of their clients. Some were quite protective of their client's security, dignity, and time, whereas some were not. Some were skeptical of the value of the study. There was a wide range in punctuality (from on-time to no-shows) of service providers in keeping appointments with the project staff.

All of the elderly who were visited by the project staff were living in group housing. To a person, these people were there because they were unable to live on their own, primarily because of dementia. They also were unable to travel by any mode on their own. The team, therefore, did not conduct focus groups with these people.

Two focus groups were conducted with low-income people. It was difficult to get individuals to commit to participate. Even after committing to attend, several people did not attend, and, of those, several were not on time. It was almost impossible to confirm attendance expectations due to their lack of telephones. Child care during the focus group was a problem for some participants.

Participation in both focus groups was enthusiastic, with people openly contributing ideas to the discussions. Participants' contributions were limited to coordination of present issues, particularly those that had an immediate impact upon their own lives. Contributions regarding future or abstract ideas were not forthcoming.

The project staff found, through experience and advice of service providers, that the best way of obtaining written information from the participants was to walk them through questionnaires question by question and to explain anything that was not clear. We, therefore, decided not to use a prefocus-group trip journal for data collection. Service providers indicated that the journals would not be completed.

C. Findings, Conclusions, and Recommendations

With anticipated demographic and economic changes, there is an expectation of need for innovative transportation for different segments of society, for drivers as well as nondrivers. As the number of elderly increase, the transportation trends emerging over the past twenty years are likely to continue into the next century. As more welfare recipients are removed from welfare and enter the workforce, more and different transportation will be needed to meet their needs. The contribution of ITS technologies in meeting emerging transportation needs of the elderly and low-income population was investigated.

A review of the literature was supplemented by focus groups with elderly and low-income people and interviews with their service providers. Several transportation attributes (e.g., safety, minimal cost, reliability, independence, etc.) desired by the participants in each group were identified and ranked. The findings of the study are organized by which intelligent transportation solutions (for both personal and public modes) are likely to contribute positively in meeting the desired transportation attributes indicated by the two populations. The problems and issues in meeting the transportation needs of the elderly and low-income populations were identified, as were current and potential solutions from across the United States.

It appears that ITS technology implementation could contribute to providing the desired transportation attributes of the elderly and the low-income populations. ITS technologies seem to be more useful for some purposes than for others. For instance, ITS may facilitate the use of public transportation by the elderly to a greater extent than it could help them in their use of private transportation. It is especially contributory in helping the elderly maintain independence, which is their primary desired transportation attribute. Furthermore, specific ITS bundles seem more beneficial to both populations than do others. The electronic payment and travel demand management bundles provide more of the stated desired attributes for both public and private transportation than do any other bundles. Transportation demand management and public transportation operations also appear to provide the transportation attributes desired by both populations.

Several specific ITS technologies contribute most strongly to the most highly desired transportation attributes. For example, low-income people rated safety as the most desired attribute for personal transportation. The ITS solutions that contribute most strongly to this attribute are advanced vehicle control safety systems. Although these technologies might not be purchased or used by low-income people, this group stands to benefit from their use in other vehicles on the road. Security is the first priority for public transportation for low-income people. ITS technologies that contribute to this include the public transportation operations technologies, smart payment cards, display of waiting time at home or bus stop, and hand-held devices for communication between the bus driver and the passengers.

Elderly people rated independence as the primary attribute desired for both personal and public transportation. Contributing to this attribute are en-route driver information, route guidance, traveler information services, ride matching, emergency notification and personal security, in-vehicle signs, obstacle detection, variable message signs, and driver-condition monitoring. For public transportation, it appears that the greatest contributions were offered by public transportation operations and travel demand management bundles along with smart payment cards, waiting time display at home or bus stop, and hand-held devices for communication between bus driver and passengers.

The framework presented in this report reveals ITS technologies that might yield the greatest benefit to specific groups of people according to those transportation attributes that they deem most important. A value of focus groups is that they provide insights to be pursued in research that is statistically based and representative of the population. Such research would provide valuable information in conducting cost/benefit analyses that would help the public and private sectors determine what investments could yield the greatest return.

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APPENDIX A
Poverty Status of Persons by Age, Ethnicity, Region, and Family Type, 1996

Category	Poverty rate (%)	Population (in 000s)	% of total population	# of poor (in 000s)	% of poverty population
Age					
Under 18	20.5	70,650	26.5	14,463	39.6
18-64	11.4	163,691	61.5	18,638	51.0
65 and over	10.8	31,877	12.0	3,428	9.4
Total	13.7	266,218	100.0	36,529	100.0
Race/Ethnicity					
White	11.2	219.656	26.5	14,463	39.6
Black	28.4	34,110	61.5	18,638	51.0
Hispanic*	29.4	29,614	12.0	3,428	9.4
Total	13.7	266,218	100.0	36,529	100.0
Family type					
Unrelated individuals	20.8	40,727	15.3	8,452	23.1
Female-headed families with children	44.3	26,798	10.1	12,750	34.9
Married-couple families	8.7	110,179	41.4	9,617	26.3
Other families with children	15.6	8,326	3.1	1,297	3.6
All other families	5.5	80,188	30.1	4,413	12.1
Total	13.7	266,218	100.0	36,529	100.0

*Persons of Hispanic origin may be of any race. Source: United States Bureau of the Census 1996b.

APPENDIX B
Composition of Poverty Population for Selected Demographic Groups, Selected Years 1959-1996

Demographic group	Year							
	1959	1966	1975	1985	1990	1992	1994	1996
Aged	13.9	17.9	12.8	10.5	10.9	10.3	9.6	9.4
Children	43.6	42.6	42.1	38.8	39.5	39.7	39.6	38.8
Non-aged adults	42.5	39.5	45.1	50.7	49.7	49.9	50.8	51.8
Individuals in female-headed families	26.3	36.0	47.4	49.5	53.4	52.6	52.8	53.5
Individuals in all other families*	73.7	64.0	52.6	50.5	46.6	47.4	47.2	46.5
Blacks	25.1	31.1	29.2	27.0	29.3	28.5	26.8	26.5
Whites	72.1	67.7	68.7	69.1	66.5	66.4	66.7	67.5
Other races	2.8	1.2	2.1	3.9	4.2	5.1	6.5	6.0
Hispanic Origin	NA	NA	11.6	15.8	17.9	20.0	22.1	23.8
Individuals in families with children	NA	NA	NA	NA	68.0	68.4	68.0	66.7
Male present	NA	NA	NA	NA	30.7	31.4	31.2	30.1
Female head	NA	NA	NA	NA	37.2	37.0	36.9	36.5
Individuals in other families	NA	NA	NA	NA	32.0	31.6	32.0	33.3

*Includes unrelated or single individuals. Source: United States Bureau of the Census 1996a.

APPENDIX C
Poverty Rates by Family Type, Selected Years, 1987-1996

Family Type	Poverty Rate, 1987-1996							1996 total (in 000s)
	1987	1988	1990	1991	1993	1994	1996	
Total								
Families	11.0	10.8	11.1	11.8	12.7	12.0	11.3	70,855
Unrelated individuals	20.4	20.6	20.7	21.1	22.1	21.5	20.8	40,727
No members age 65 or over								
Families	11.9	11.6	12.2	13.0	14.0	13.1	12.4	57,470
Unrelated individuals	19.1	19.3	19.1	19.6	21.3	20.9	20.7	30,017
Any Member age 65 or over								
Families	7.2	6.9	6.4	6.7	7.0	6.9	6.4	13,385
Unrelated individuals	23.9	24.1	24.7	24.9	24.1	23.1	20.9	10,709
Families with children								
Female-headed family, no husband present	46.3	45.5	45.3	47.6	46.7	44.6	42.3	9,444
Male-present families	8.1	7.7	8.5	9.0	9.9	9.3	8.5	28,354

Source: Congressional Research Service 1999.

APPENDIX D
Number of Person Trips by Household Income and Mode of Transportation
1990 NPTS (Millions)

MODE	Under $10,000	$10,000-19,999	$20,000-29,999	$30,000-39,999	$40,000- and More	Unreported Income	Total
PRIVATE VEHICLE							
Auto, Van-Driver	6,850	15,043	18,567	19,495	46,675	29,582	136,212
	(41.6%)	(52.6%)	(53.9%)	(54.3%)	(58.1%)	(54.9%)	(54.6%)
Auto, Van-Passenger	3,465	5,911	7,277	7,475	17,594	11,592	53,314
	(21.0%)	(20.7%)	(21.1%)	(20.8%)	(21.9%)	(21.5%)	(21.4%)
Pickup	1,145	2,939	3,981	4,460	8,064	5,043	25,633
	(7.0%)	(10.3%)	(11.6%)	(12.4%)	(10.0%)	(9.4%)	(10.3%)
Other Private Vehicle	60	287	318	409	740	420	2,233
	(0.4%)	(1.0%)	(0.9%)	(1.1%)	(0.9%)	(0.8%)	(0.9%)
Subtotal-Private	11,520	24,180	30,143	31,839	73,073	46,637	217,392
	(70.0%)	(84.6%)	(87.6%)	(88.7%)	(90.9%)	(86.6%)	(87.1%)
PUBLIC TRANSPORTATION							
Bus, Streetcar	556	666	490	315	537	979	3,543
	(3.4%)	(2.3%)	(1.4%)	(0.9%)	(0.7%)	(1.8%)	(1.4%)
Rail/Subway[2]	49	129	199	146	448	379	1,349
	(0.3%)	(0.4%)	(0.6%)	(0.4%)	(0.6%)	(0.7%)	(0.5%)
Subtotal-Public	605	795	689	461	986	1,358	4,892
	(3.7%)	(2.8%)	(2.0%)	(1.3%)	(1.2%)	(2.5%)	(2.0%)
OTHER MEANS							
Amtrak	20	7	**	3	24	1	54
	(0.1%)	0.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)
Walk	3,513	2,440	2,442	2,142	3,669	3,802	18,007
	(21.3%)	(8.5%)	(7.1%)	(6.0%)	(4.6%)	(7.1%)	(7.2%)
Bike	186	205	292	329	477	278	1,767
	(1.1%)	(0.7%)	(0.8%)	(0.9%)	(0.6%)	(0.5%)	(0.7%)
School Bus	489	757	748	954	1,708	1,437	6,092
	(3.0%)	(2.7%)	(2.2%)	(2.7%)	(2.1%)	(2.7%)	(2.4%)
Airplane	2	27	7	32	86	48	203
	(0.0%)	(0.1%)	(0.0%)	(0.1%)	(0.1%)	(0.1%)	(0.1%)
Taxi	81	20	45	47	118	110	422
	(0.5%)	(0.1%)	(0.1%)	(0.1%)	(0.1%)	(0.2%)	0.2%)
Other	21	94	41	80	159	132	527
	(0.1%)	(0.3%)	(0.1%)	(0.2%)	(0.2%)	(0.2%)	(0.2%)
Subtotal-Other	4,311	3,550	3,575	3,588	6,241	5,808	27,071
	(26.2%)	(12.4%)	(10.4%)	(10.0%)	(7.8%)	(10.8%)	(10.8%)
TOTAL[3]	16,456	28,568	34,426	35,915	80,345	53.851	249,562
	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)

**Indicates no data reported. Source: Hu and Young (1994), table 4.34.

[1]Estimates of transit use are based on a total of 2870 travel day trips on transit in the NPTS sample. The NPTS estimate of transit trips is 20% lower than the Federal Transit Administration's Section 15 reporting system.

[2] Rail/Subway includes trips by subway, elevated rail and commuter train.

[3] Includes trips where mode of transportation was unreported.

APPENDIX E
Number of Person Miles of Travel By Household Income and Mode of Transportation 1990 NPTS (Millions)

MODE	Under $10,000	$10,000-19,999	$20,000-29,999	$30,000-39,999	$40,000-and More	Unreported Income	Total
PRIVATE VEHICLE							
Auto, Van-Driver	47,583	105,658	151,974	173,167	443,224	250,423	1,172,029
	(48.1%)	(44.0%)	(53.0%)	(50.9%)	(51.8%)	(50.8%)	(50.6%)
Auto, Van-Passenger	30,889	62,280	69,171	78,653	206,949	117,100	565,042
	(31.2%)	(25.9%)	(24.1%)	(23.1%)	(24.2%)	(23.7%)	(24.4%)
Pickup	11,536	27,615	42,612	45,281	89,289	51,612	267,944
	(11.7%)	(11.5%)	14.9%)	(13.3%)	(10.4%)	(10.5%)	(11.6%)
Other Private Vehicle	232	5,156	5,260	7,996	10,646	5,677	34,967
	(0.2%)	(2.1%)	(1.8%)	(2.3%)	(1.2%)	(1.2%)	(1.5%)
Subtotal-Private	90,240	200,709	269,017	305,097	750,108	424,812	2,039,982
	(91.2%)	(83.5%)	(93.8%)	(89.6%)	(87.6%)	(86.2%)	(88.1%)
PUBLIC TRANSPORTATION							
Bus, Streetcar	3,066	8,590	3,396	3,950	7,081	9,106	35,189
	(3.1%)	(3.6%)	(1.2%)	(1.2%)	(0.8%)	(1.8%)	(1.5%)
Rail/Subway[2]	497	1,216	2,454	2,703	6,930	4,058	17,858
	(0.5%)	(0.5%)	(0.9%)	(0.8%)	(0.8%)	(0.8%)	(0.8%)
Subtotal-Public	3,563	9,806	5,850	6,653	14,011	13,164	53,047
	(3.6%)	(4.1%)	(2.0%)	(2.0%)	(1.6%)	(2.7%)	(2.3%)
OTHER MEANS							
Amtrak	233	2,156	**	45	2,653	21	5,108
	(0.2%)	(0.9%)	(0.0%)	(0.0%)	(0.3%)	(0.0%)	(0.2%)
Walk	1,798	1,591	1,518	1,251	2,554	2,705	11,418
	(1.8%)	(0.7%)	(0.5%)	(0.4%)	(0.3%)	(0.5%)	(0.5%)
Bike	347	373	357	678	1,127	589	3,471
	(0.4%)	(0.1%)	(0.1%)	(0.2%)	(0.1%)	(0.1%)	(0.1%)
School Bus	2,111	4,437	5,087	5,198	9,723	6,886	33,442
	(2.1%)	(1.8%)	(1.8%)	(1.5%)	(1.1%)	(1.4%)	(1.4%)
Airplane	**	20,614	4,553	20,504	71,323	27,901	144,895
	(0.0%)	(8.6%)	(1.6%)	(6.0%)	(8.3%)	(5.7%)	(6.3%)
Taxi	366	137	54	259	661	293	1,770
	(0.4%)	(0.1%)	(0.0%)	(0.1%)	(0.1%)	(0.1%)	(0.1%)
Other	265	413	281	615	3,569	16,057	21,200
	(0.3%)	(0.2%)	(0.1%)	(0.2%)	(0.4%)	(3.2%)	(0.9%)
Subtotal-Other	5,120	29,720	11,850	28,550	91,610	54,452	221,303
	(5.2%)	(12.4%)	(4.1%)	(8.4%)	(10.7%)	(11.0%)	(9.6%)
TOTAL[3]	98,927	240,395	286,722	340,376	856,002	492,850	2,315,273
	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)

**Indicates no data reported. Source: Hu and Young (1994), table 4.34.

[1] Estimates of transit use are based on a total of 2870 travel day trips on transit in the NPTS sample. The NPTS estimate of transit trips is 20% lower than the Federal Transit Administration's Section 15 reporting system.

[2] Rail/Subway includes trips by subway, elevated rail and commuter train.

[3] Includes trips where mode of transportation was unreported.

APPENDIX F
Number of Person Trips and Person Miles by Mode of Transportation for Household Income ≤ $10,000 1990 NPTS (Millions)

	Number of Person Trips Under $10,000	Number of Person Miles Under $10,000
PRIVATE VEHICLE		
Auto, Van-Driver	6,850	47,583
	(41.6%)	(48.1%)
Auto, Van-Passenger	3,465	30,889
	(21.0%)	(31.2%)
Pickup	1,145	11,536
	(7.0%)	(11.7%)
Other Private Vehicle	60	232
	(0.4%)	(0.2%)
Subtotal-Private	11,520	90,240
	(70.0%)	(91.2%)
PUBLIC TRANSPORTATION		
Bus, Streetcar	556	3,066
	(3.4%)	(3.1%)
Rail/Subway[2]	49	497
	(0.3%)	(0.5%)
Subtotal-Public	605	3,563
	(3.7%)	(3.6%)
OTHER MEANS		
Amtrak	20	233
	(0.1%)	(0.2%)
Walk	3,513	1,798
	(21.3%)	(1.8%)
Bike	186	347
	(1.1%)	(0.4%)
School Bus	489	2,111
	(3.0%)	(2.1%)
Airplane	2	**
	(0.0%)	(0.0%)
Taxi	81	366
	(0.5%)	(0.4%)
Other	21	265
	(0.1%)	(0.3%)
Subtotal-Other	4,311	5,120
	(26.2%)	(5.2%)
TOTAL[3]	16,456	98,927
	(100.0%)	(100.0%)

**Indicates no data reported. Source: Hu and Young (1994), table 4.34 and 4.35.

[1] Estimates of transit use are based on a total of 2870 travel day trips on transit in the NPTS sample. The NPTS estimate of transit trips is 20% lower than the Federal Transit Administration's Section 15 reporting system.

[2] Rail/Subway includes trips by subway, elevated rail and commuter train.

[3] Includes trips where mode of transportation was unreported.

APPENDIX G
Percentage of Person Miles of Travel by Trip Purpose by Household Income Groups, 1983 and 1990

		Annual Household Income*						
Trip Purpose	**Year**	**<$10,000**	**$10,000 - $19,999**	**$20,000 $29,999**	**$30,000 - $39,999**	**>$40,000**	**Unreported income**	**Total**
Earning a Living	1983	15.5%	26.3%	29.0%	28.6%	26.7%		26.3%
	1990	19.2%	22.9%	23.7%	25.4%	30.1%	27.9%	26.9%
Family and Personal Business	1983	28.8%	29.4%	26.3%	23.6%	22.0%		24.9%
	1990	38.3%	32.3%	35.5%	30.1%	28.3%	32.9%	31.3%
Civic, Education & Religious	1983	7.6%	6.9%	6.6%	5.2%	7.1%		6.7%
	1990	9.6%	7.9%	6.7%	6.6%	5.6%	6.4%	6.4%
Social & Recreational	1983	44.1%	35.3%	36.5%	41.0%	42.0%		40.0%
	1990	31.9%	36.5%	32.6%	37.4%	35.2%	32.1%	34.5%
Other	1983	4.0%	2.1%	1.6%	1.6%	2.2%		2.1%
	1990	1.0%	0.4%	1.5%	0.5%	0.8%	0.6%	0.8%
Total	1983	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
	1990	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Number of Households	1983	21.2%	21.6%	18.4%	14.1%	24.8%		100.0%
	1990	9.9%	13.9%	13.2%	12.1%	23.3%	27.6%	100%
Person Miles Per Household	1983	10,656	16,566	22,506	27,190	36,283		22,802
	1990	10,692	18,473	23,321	30,057	39,435		

*Incomes are in 1990 dollars. Income was imputed where not reported. Source: Hu and Young. (1994), table 4.31, Parts 1 and 2.

APPENDIX H
Average Daily Person Trips, Person Travel, and Person Trip Length by Household Income and Trip Purpose, 1990

	Annual Household Income*				
Trip Purpose	<$10,000	$10,000 - $19,999	$20,000 - $29,999	$30,000 - $39,999	>$40,000
Average Daily Person Trips					
Earning a Living	0.3	0.6	0.7	0.7	0.8
Family and Personal Business	1.1	1.2	1.4	1.4	1.4
Civic, Educational, and Religious	0.4	0.3	0.3	0.4	0.4
Social and Recreational	0.7	0.7	0.8	0.8	0.9
Other	0.1	0.1	0.1	0.1	0.1
TOTAL	2.6	2.9	3.3	3.4	3.6
Average Daily Person Miles of Travel					
Earning a Living	3.1	5.5	6.4	8.1	11.4
Family and Personal Business	6.1	7.7	9.7	9.6	10.7
Civic, Educational, and Religious	1.5	1.9	1.8	2.1	2.1
Social and Recreational	5.1	8.7	8.9	11.9	13.3
Other	0.2	0.1	0.4	0.2	0.3
TOTAL	16.0	23.9	27.2	31.9	37.8
Average Person Trip Length (miles)					
Earning a Living	9.3	10.0	9.6	11.0	13.9
Family and Personal Business	5.5	6.4	6.9	6.9	7.5
Civic, Educational, and Religious	3.6	6.0	5.5	5.7	5.8
Social and Recreational	7.4	12.5	11.2	14.8	15.1
Other	5.8	6.1	17.1	7.9	11.6
ALL PURPOSES	6.2	8.6	8.5	9.6	10.8

*Average trip length is calculated only for records where trip mile information is present. Source: Hu and Young. (1994), table 4.32.

APPENDIX I
Average Daily Person Trips, Person Travel, and Person Trip Length by Trip Purpose for Household Income ≤ $10,000, 1983, 1990

Trip Purpose	Average Daily Person Trips	Average Daily Person Miles of Travel (miles)	Percent of Person Miles of Travel	Average Person Trip Length (miles)
Earning a Living	0.3	3.1	'83 15.5% '90 19.2%	9.3
Family and Personal Business	1.1	6.1	'83 28.8% '90 38.3%	5.5
Civic, Educational and Religious	0.4	1.5	'83 7.6% '90 9.61%	3.6
Social and Recreational	0.7	5.1	'83 44.1% '90 31.9%	7.4
Other	0.1	0.2	'83 4.0% '90 1.0%	5.8
Total	2.6	16.0		6.2
Number of Households	'83 21.2% '90 9.9%			
Person Miles Per Household	'83 10,656 '90 10,692			

Source: Hu and Young (1994), tables 4.31 and 4.32.

APPENDIX J
Focus Group Questionnaire

University of Michigan Transportation Research Institute
Transportation Survey – Part I

1) NAME _____

2) ADDRESS
Street _____ apt. _____
City _____ State _____ Zip code _____

3) PHONE NUMBER _____

4) DATE OF BIRTH (month / day / year) ____/____/____

5) GENDER – Please check one: MALE_____ FEMALE_____

6) RACE / ETHNICITY - Please check one:

WHITE	_____	AFRICAN-AMERICAN	_____
LATINO/LATINA	_____	ASIAN/PACIFIC ISLANDER	_____
NATIVE AMERICAN	_____	OTHER_____	

7) EDUCATION – Please check highest level completed:

SOME HIGH SCHOOL	_____	COLLEGE GRADUATE	_____
HIGH SCHOOL GRADUATE	_____	MASTERS DEGREE	_____
SOME COLLEGE / JUNIOR COLLEGE	_____	PHD / DOCTORATE	_____

8) EMPLOYMENT – Please list all positions you have held in the last 5 years:

POSITION	Type of Company (manufacturing, hotel, retail, etc.)	DATES WORKED
		TO
		TO
		TO
		TO
		TO
		TO

9) ANNUAL HOUSEHOLD INCOME - Please check one:

LESS THAN $10,000	_____	$10,000 - $20,000	_____
$20,000 - $30,000	_____	$30,000 - $40,000	_____
$40,000 - $50,000	_____	Greater than $50,000	_____

10) FAMILY STATUS – Please check one:

MARRIED	_____	DIVORCED	_____
SINGLE	_____	WIDOWED	_____

LIVING WITH SIGNIFICANT PARTNER _____ OTHER_____

11) How many children do you have? _____

CHILDREN

Gender (M or F)	Age	Does the child live with you? (Yes or No)	How does your child spend weekdays? (home, school, daycare, work, other – please explain)	If your child does not live with you, do they live within 20 minutes driving? (Yes or No)

12) Do you currently have a driver's license? YES _____ NO _____

12a) If NO, did you ever have a driver's license? YES _____ NO _____

13) If you do not currently have a driver's license but did have one in the past, why did you allow your license to expire? Please explain.

_____

_____

_____

14) Do you currently own or lease a car? YES_____ NO_____

14a) If YES, how many?_____

Age of Vehicles 1st vehicle_____ 2nd vehicle_____ 3rd vehicle____

14b) If NO, why not? Please explain. _____

_____

_____

_____

15) Do you currently drive? YES_____ NO _____

16) Do any of the following conditions influence your decision not to drive? Please check all that apply:

poor vision _____ do not have a license _____

physical disability	_____	car too expensive	_____
slow response time	_____	car insurance too expensive	_____
illness	_____	fuel / maintenance too expensive	_____
fear of driving	_____	inconvenient / unsafe	_____

other_____

17).Do any of the following conditions influence your decision to use public transportation? Please check all that apply:

poor vision	_____	too expensive	_____
physical disability	_____	fear of public transportation	_____
illness	_____	dislike of public transportation	_____
lack of information	_____	inconvenient / unsafe	_____

other_____

18). How far is the nearest bus stop from your home?

within 1 block	_____	within 4 blocks	_____
within 2 blocks	_____	5 or more blocks	_____
within 3 blocks	_____		

19) Does the bus service provide direct access to your desired destination?

YES_____ NO_____

20) What problems, difficulties, or fears do you have with public transportation? Please explain.

_____

_____

_____

21) What are your usual transportation destinations?

22) Where would you like to go but are unable to get there? How often would you like to go there? During what time of day would you like to go?

23) What new transportation services do you think would help meet your transportation needs?

24) What ideas, thoughts, or suggestions do you have?