Mobility in an Aging America:

Design, Licensing, and Alternative Transportation Options

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Executive Summary

The number of people over the age of 65 in the United States increased eleven-fold during the 20th century compared to only a threefold increase for those under 65. Keeping this segment of the population safely mobile is becoming an increasing public policy concern. Through research and conversations with transportation professionals, the focus of this analysis was narrowed to three primary issues: 1) Transportation System Design Standards and Practices, primarily focused on driving issues, 2) Alternative Licensing Practices, targeted specifically to renewal or revocation procedures, and 3) Alternative Transportation Opportunities on a local scale.

Our research in the area of transportation system design standards indicated various problems with sign perception and understanding. Particular design practices used in intersection and highway construction seem to overestimate the overall perception reaction times actually demonstrated by the elderly, leading to an increased crash rates in those places. Second, we found that alternative licensing procedures have had limited effectiveness in lowering the crash and fatality rates of older drivers. Many states have attempted to restrict license renewal periods, but no conclusive evidence could be found to confirm the connection between shorter renewal cycles and lower crash rates. Studies have shown, however, that a higher percentage of older drivers involved in crashes are afflicted with some form of impairing medical condition. Finally, our research of alternative transportation methods presented three innovative approaches to helping older citizens retain their mobility, some of which may provide responsive and user-friendly transportation options for elderly.

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Overview

The number of people over the age of 65 in the United States increased eleven-fold during the 20th century compared to only a threefold increase for those under 65 (USDOT, 1997). Most studies indicate that Americans are living longer, with many living through an extended period of health and activity beyond age 80. The older adult group, which numbered 33.5 million in 1995, or 12.8 percent of the population, is projected to grow to 36.2 million by 2005. By the year 2020, it is apt to be 53.2 million, or 16.5 percent of the population (USDOT, 1997). Such a dramatic shift in the demographics will have a tremendous impact on all elements of the American society. Changes in housing, shopping areas, and government sponsored recreational activities will all occur in the next few decades to accommodate the increased percentage of older Americans in the population. An area of increasing concern at the federal, state, and local level is the ability to provide mobility options for older Americans.

Mobility is one of the benchmarks of American culture (see Black 2000). There are more personal vehicles in the nation than licensed drivers (USDOT, 1997). Except for persons living in large cities, the primary constraint on full mobility in the lives of Americans comes when advancing age begins to erode capacities necessary for the safe operation of a vehicle. Those aged 75 and above pose a particular concern: by applying today's fatality rates to this group, we see that traffic deaths could increase 45 percent (and possibly higher according to other estimates) unless the efforts of the safety community can dramatically lower their crash rate or increase their likelihood of surviving a crash. If safe, affordable transportation alternatives are not available—often the case for the rural or suburban elderly—their quality of life is diminished. Research shows that individuals who must stop driving experience "lower life satisfaction, poorer adjustment, loneliness, and lower activity levels" (AARP Public Policy Institute, 2000).

Since it is also in the public interest to keep transportation fatality and injury rates low, adequate strategies must be adopted to keep older persons safe as they move about. Quality of life considerations for the elderly lead to recommendations that keep people driving personal vehicles as long as possible (while maintaining public safety in general). It is also in the public interest to maintain the productivity and value added to the national economy of those older adults who operate vehicles commercially. With these values in mind, we suggest that more stringent screening and evaluation measures are necessary to account for the higher public risks presented by those operating commercial vehicles at advanced ages. No two people age the same; some forty-year-old drivers may be a larger risk than some 80-year-old operators. No matter which policy options are pursued some constituencies will be dissatisfied, so it is important to examine advantages and disadvantages of each broad policy option.

This document presents these broad policy areas involving the growing population of older drivers and offers specific policy recommendations to the Wisconsin Department of Transportation, Safety Division. Through research and conversations with transportation professionals, we narrowed the focus of this analysis to three primary issues: 1) Transportation System Design Standards and Practices, primarily focused on driving issues, 2) Alternative Licensing Practices, targeted specifically to renewal or revocation procedures, and 3) Alternative Transportation Opportunities on a local scale. Each is presented as a brief chapter.

Basic Safety Information

> *Older drivers are over-represented in crashes at intersections and/or involving failure to yield the right of way, unseen objects, and failure to heed stop signs or signals. Crashes occurring while turning and changing lanes were also more common among older drivers. The strength of older drivers lies in their aversion to risk, but perceptual problems and difficulty judging and responding to traffic flow often counterbalance this attribute.*
>
> McGwin, G., Brown, D.B. (1999). Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention*, Vol. 31, No. 3, pp. 181.

The data clearly indicate that when elderly people do drive, they pose a greater safety risk than younger drivers, especially per mile driven. Table 1 shows the increase in traffic fatalities nationwide as drivers age. Elderly drivers are also more likely to get traffic citations for failing to yield, turning improperly, and running stop signs and red lights (California Department of Motor Vehicles and Beverly Foundation, 1997).

Table 1
PERCENT DISTRIBUTION OF PASSENGER VEHICLE DRIVERS IN FATAL CRASHES BY TYPE, 1998

Age	Multiple Vehicle Intersect	Single Vehicle	All Other
16-19	22	46	31
20-24	21	46	33
25-29	24	40	36
30-34	24	37	39
35-39	26	37	38
40-44	24	36	39
45-49	24	34	42
50-54	28	32	40
55-59	26	31	42
60-64	29	29	41
65-69	31	28	42
70-74	36	28	35
75-79	44	24	31
80-84	48	22	29
>=85	55	17	28

Source: Insurance Institute for Highway Safety

Table 2
PASSENGER VEHICLE DRIVER DEATHS PER 100,000 LICENSED DRIVERS, 1998

Age	Male	Female	All
16-19	33	16	24
20-24	26	10	19
25-29	16	7	12
30-34	13	6	9
35-39	13	6	10
40-44	12	5	8
45-49	12	5	9
50-54	11	5	8
55-59	11	6	8
60-64	11	5	8
65-69	14	7	10
>=70	**23**	**12**	**17**

Source: National Highway Transportation Safety Administration, 1999.

Once they are in crashes, elderly people are more susceptible than younger people are to medical complications resulting from motor vehicle crash injuries (Crary, 1999). Consequently, they are more likely to die from their injuries. Table 2 indicates that only those under age 25 have more fatalities than those over 65 per 100,000 licensed drivers. When the number of vehicle miles driven is calculated (which is low for the elderly relative to younger drivers), the fatality statistics increase even more dramatically with respect to other age groupings.

The following facts are based on analysis of data from the U.S. Department of Transportation's Fatality Analysis Reporting System:

- 7,269 people 65 years and older died in motor vehicle crashes in 1998. This represents a 2 percent drop since 1997 and a 36 percent increase since 1975.
- Eighty-one percent of elderly killed in 1998 motor vehicle crashes were passenger vehicle occupants, and 16 percent were pedestrians.
- People 65 years and older represented 13 percent of the population in 1998 and 18 percent of motor vehicle deaths. By 2030, elderly people are expected to represent 20 percent of the population and nearly 45 percent of fatalities.

Table 3 indicates the emerging trend in increased traffic fatalities for older drivers. (Not adjusted for general increase in population for individuals over 65.)

Table 3
MOTOR VEHICLE DEATHS, PEOPLE 65 YEARS AND OLDER

	Passenger Vehicles	Pedestrians	Other	Total
1975	3,391	1,744	191	5,326
1976	3,556	1,663	175	5,394
1977	3,431	1,779	164	5,374
1978	3,653	1,608	165	5,426
1979	3,480	1,685	180	5,345
1980	3,426	1,728	187	5,341
1981	3,513	1,628	171	5,312
1982	3,388	1,449	168	5,005
1983	3,528	1,388	161	5,077
1984	3,854	1,463	188	5,505
1985	3,961	1,454	157	5,572
1986	4,271	1,430	202	5,903
1987	4,451	1,483	194	6,128
1988	4,771	1,596	185	6,552
1989	4,911	1,467	186	6,564
1990	4,715	1,503	209	6,427
1991	4,897	1,292	175	6,364
1992	4,939	1,272	165	6,376
1993	5,179	1,259	207	6,645
1994	5,485	1,264	197	6,946
1995	5,537	1,263	199	6,999
1996	5,691	1,210	212	7,113
1997	5,954	1,174	280	7,408
1998	5,857	1,168	244	7,269

Source: Insurance Institute for Highway Safety

In Wisconsin specifically, during 1998 drivers 65 and older were involved in nearly 21 percent of fatal crashes per one hundred million vehicle miles traveled, while comprising only 14 percent of the licensed drivers (Wisconsin DOT, 1999).

Road Design

According to some analysts, older drivers behave overconfidently as they handle risky situations (Charness, 1992). If this is so, they are unlikely to admit to difficulties concerning transportation design issues. Several specific design challenges exist, however, and a great deal of effort has been undertaken to help older drivers by improving road design. Three specific areas require analysis: traffic control devices, including signs and traffic signals; geometric design; and Intelligent Vehicle Systems.

Traffic Control Devices

The Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, 1988) states that traffic control devices function "to direct and assist vehicle operators in the guidance and navigation tasks required to traverse safely any facility open to public travel." Four primary types of safety devices exist: highway signs, traffic signals, delineation (painted stripes, raised pavement markers, and post-mounted markers), and object markers.

Traffic Signs. One cause of accidents involving senior drivers is failure to heed traffic signs (Alicandri, 1994). Four characteristics of older drivers may contribute to this: poorer vision, reduced cognitive ability, increased difficulty with dividing attention among tasks (multitasking), and lack of familiarity with highway signs and painted markings. To serve the needs of older drivers, traffic signs must be sufficiently conspicuous, legible, and understandable to overcome the slower perceptual and cognitive deteriorations that can occur with aging (Alicandri, 1994).

Efforts to address these problems have focused on making traffic signs bigger and brighter. A 1990 study showed that for older drivers to read signs as well as their younger counterparts, they might need sign letters to be 30 percent larger (Dewar, Kline & Swanson, 1994). Since a one-third increase in letter size may require a 60 to 80 percent increase in sign size, making letters bigger becomes an extremely expensive solution (Alicandri, 1994). A 1994 study showed that younger drivers could read traffic signs farther away in daylight than in darkness (600 feet in daylight and 300 feet at night). Older drivers, however, needed as much distance to read a sign during the day as they did at night. Experiments with taller lettering on traffic signs showed that making letters more than 16 inches high brought diminishing results.

One option being pursued involves redundant signing, a repeated placement of identical signs at shorter intervals in advance of an approaching obstacle. This sometimes improves accuracy and speed of decision making for older drivers. One problem, however, is that redundant signing may cause some difficulty with clutter -- another problem for older drivers. Consequently, highway designers must balance the benefits of redundant signing against the confusion caused by too much background clutter.

Certain studies showed that regulatory and construction signs meeting legibility requirements for younger drivers safely satisfied the needs of only 85 percent of older drivers (Alicandri, 1994). Guide signs, such as bridge and curve markers, meeting the requirements of younger drivers met the needs of only 50 percent of older drivers. Further analysis showed that "larger signs with engineering grade materials are generally more cost effective/efficient that smaller signs with diamond grade sheeting for initial implementation" (Benekohal, 1997). The authors also recommended more research in these areas.

Another FHWA study addressed the benefits of using symbol signs rather than text signs--a practice that has been increasing in popularity since the 1970s (Dewar, Kline, & Swanson, 1994). Of the 85 signs investigated, only 28 were understood by more than 90 percent of respondents, and 10 signs were understood by only 10 percent of respondents. Younger drivers showed a better understanding of 39 percent of the symbol signs than did older drivers. As with text signs, older drivers showed longer recognition distances for symbol signs than their young and middle-aged counterparts. Appendix 1 presents the summary report for the study complete with samples of sign changes. Moreover, recognition distances for older drivers varied significantly from sign to sign and from daytime to darkness. The slowed cognitive ability of older drivers demands that signs be simple to understand.

Traffic Signals. Roadway standards allow considerable latitude in signal design and placement; thus not all traffic signals look alike nor are they placed consistently in different intersections. A disproportionate percentage of traffic crashes occur at intersections – especially when drivers are required to make a left hand turn. Older drivers react more slowly to lighting than their younger counterparts do; therefore, this lack of consistency may create a hazard for senior motorists (Alicandri, 1994). Standardization of traffic signal placement may work to eliminate this problem.

Delineation. Delineators generally are defined as "painted stripes on the road, raised pavement markers, and post-mounted delineators used to define lanes, road edges and other geometric features of the highway system" (Benekohal et al., 1997). Delineation improvement experiments have included widely spaced raised pavement markers (twice as far apart as the current standard) and a new design for post-mounted delineators. The results indicated that older drivers were particularly assisted during night driving conditions with these pavement markers. Enhanced roadway delineators would help older motorists, especially in difficult nighttime driving situations.

Object Markers. Object markers that identify oncoming traffic obstacles are consistently among the most difficult traffic control devices to comprehend. Studies focusing on the most effective size, shape, and color for markers showed that research participants noticed only 39 percent of the object markers they viewed in slide-based test situations (FHWA, 1995). Best understood were standard road edge markers (1-by-3-foot vertical rectangles with black and yellow 45-degree stripes) followed by markers with small yellow or white rectangles with yellow reflective buttons. Least effective were the common warning markers (18-inch yellow diamonds or yellow or black diamonds with reflective yellow buttons). Preferences varied according to the age of drivers. Older drivers preferred diamonds or circles that depicted the actual hazard on a white background, and younger drivers preferred square signs with abstract symbols and green or yellow-green backgrounds. No color preferences for the symbols were noted in these studies.

Geometric Design

Standards for roadway geometric designs – including turning radii and similar elements – depend on human factor requirements such as intersection sight distance, stopping sight distance, and decision sight distance (AASHTO, 2000). While all sight-distance requirements seem to increase with age, the American Association of Highway and Transportation Officials' (AASHTO's) standard, providing two seconds of perception-reaction time for intersection sight distance seemed adequate for drivers of all ages (Alicandri, 1994). Researchers have also observed that younger drivers show shorter average perception-reaction times for stopping sight distance than older drivers; however, AASHTO's design value of 2.5 seconds stopping sight distance also proved adequate for all drivers. Older drivers typically compensate for increased perception-reaction times by such strategies as reducing driving speeds and eliminating distractions within their vehicles (Crary, 1999).

Older drivers generally have slower perception-reaction times than younger drivers in situations requiring them to make complex decisions or execute unexpected maneuvers. Researchers found that overall perception-reaction times in such situations for drivers 20 to 40 years old were 3.6 seconds compared with 4.5 seconds for 65- to 69-year-olds and 5.5 seconds for drivers 70 and over (FHWA, 1997).

FHWA is giving special attention to problems older drivers encounter on freeways when they must make such high-speed decisions as merging and changing lanes. These complex driving

tasks require an ability to comprehend visual input from more than one direction and make accurate, quick decisions. Since these abilities deteriorate with age, older drivers require more time to make safe merging and lane-changing decisions on high-speed roadways.

Intersections present another instance where driving requires quick and accurate decision making and complex maneuvering in response to numerous stimuli. Statistics show that seniors are over-represented in intersection accidents (FHWA, 1997). Older drivers have revealed problems with skewed intersections, particularly where intersection angles of more or less than 90 degrees required tight left turns. Older drivers expressed a preference "for turn lanes separated by some type of physical barrier from other traffic and for raised or painted pavement on the left-side of a left-turn bay." (Paniati, 1994) To find ways to decrease accident rates at intersections for older drivers, FHWA is conducting a field study entitled "Traffic Operations Control for Older Drivers" using offset left-turn lanes and larger turning radii.

Intelligent Vehicle Highway Systems (IVHS)

Government agencies and private industry are joining colleges and universities in developing Intelligent Vehicle-Highway System (IVHS) technology "to improve travel efficiency and mobility, enhance safety, conserve energy, provide economic benefits, and protect the environment" (USDOT website). One part of IVHS, Advanced Traveler Information Systems (ATIS), focuses on providing in-vehicle information to drivers about routes, services, roadway signs, and upcoming hazards. Studies to decide whether to use flat or three-dimensional in-vehicle images show that speed and accuracy of response to ATIS information are better for younger drivers than for older persons (Transportation Development Center, 1998). Further studies will compare the benefits of heads-up versus in-dashboard displays for younger, middle-aged, and older drivers.

Licensing and Renewal

From 1988 to 1998, the percentage of the population over age 70 increased by 22 percent, while in the same ten-year span of time the fatality per crash rate in this same population increased by 45 percent. (Traffic Safety Facts, 1998) Statistics such as these compounded with the reality of an increasingly aging population has induced states and provinces to take a wide variety of policy actions in an attempt to deal with the issue of aging drivers. These licensing policies have come in three general areas: shortening renewal periods for individuals of advancing age, medical reporting requirements for individuals of advancing age, and programs where concerned family, doctors, or law enforcement can refer individuals of concern to the state licensing agency. The licensing agency then assesses these individuals ability to drive, and if deemed necessary make restrictions in driving privileges.

Licensing and renewal requirements

Changing the testing requirements for licensing and time between renewals for older drivers is one type of policy action taken by states and Canadian provinces to deal with the issues of an aging driving population. These laws have come despite the position stated by the American Association of Retired Persons (AARP) that "age based testing is discriminatory and arbitrary" (AARP, 1995). Table 4 illustrates the variation in licensing and renewal requirements for older drivers in the United States.

Table 4: State Licensing Renewal Policies

State	Length of Renewal	Accelerated Renewal	Other Provisions	% of pop over 65 (1996)	% of fatalities over 65 (1996)
Alabama	4 yr.	None	None	13.10%	14.10%
Alaska	5 yr.	None	Mail renewal not available to people 65 and older and to people whose prior renewal was by mail.	5.10%	13.30%
Arizona	12 yrs	5 yrs after 65	None	13.40%	16.70%
Arkansas	4 yr.	None	None	14.50%	13.50%
California	5 yr.	None	At age 70, mail renewal is prohibited. No more than two sequential mail renewals are permitted, regardless of age.	11.10%	16.60%
Colorado	5 yr.	None	Mail renewal not available to people 66 and older and to people whose prior renewal was by mail.	10.10%	14.70%
Connecticut	4 yr.	None	None	14.40%	16.80%
Delaware	5 yr.	None	None	12.90%	17.30%
D. C.	4 yr.	None	Diabetics 70 and older must be cleared by a medical review board. Applicants for renewal 70 and older must take a vision test and may have to take a reaction test and must submit a physician's statement that they are physically and mentally qualified to drive. At age 75, renewal applicants may be required to take written and road tests.	13.90%	15.10%
Florida	6 yr. Clean record 4yrs. if not clean	None	None	18.50%	23.80%

Georgia	4 yr.	None	None	10%	13.60%
Hawaii	6 yr.	2yr. Older than 72	None	13%	16.90%
Idaho	4 yr.	Effective 1/2/2000 until 1/1/2001, drivers ages 21-62 have the choice of a 4- or 8-yr. license; drivers 63 and older will	None	11.40%	17.80%
Illinois	4 yr.	2 yr. for prior drivers 87 81-86; 1 yr. F and older	Renewal applicants 75 and older must take a road test.	12.50%	17.30%
Indiana	4 yr.	3yrs. 75 and older	None	12.70%	17.20%
Iowa	2 or 4 yr. at driver's Option	2yrs for 70 and older	None	12.70%	18.30%
Kansas	6 yr.	4 yr. 65 and older	None	15.20%	18.30%
Kentucky	4 yr.	None	None	12.60%	15%
Louisiana	4 yr.	None	Mail renewal not available to people 70 and older and to people whose prior renewal was by mail.	12%	12.40%
Maine	6 yr.	4yrs 65 and older	Vision test required at first renewal after driver's 40th birthday and at every second renewal until age 62; thereafter, at every renewal.	14.00%	23.70%
Maryland	5 yr.	None	None that are safety related	11.40%	18.20%
Massachusetts	5 yr.	None	None that are safety related	14.10%	24%
Michigan	4 yr.	None	None	12.50%	17.70%
Minnesota	4 yr.	None	None that are safety related	12.50%	17.90%
Mississippi	4 yr.	None	None	12.30%	13.60%
Missouri	3 yr.	None	None	13.90%	16%
Montana	8 yr.	4 yrs 75 and older	None	13.20%	15%
Nebraska	5 yr.	None	None	13.90%	18.40%
Nevada	4 yr.	None	None that are safety related	11.50%	15.50%
New Hampshire	4 yr.	None	Renewal applicants age 75 and older must take a road test.	12.10%	23.10%
New Jersey	4 yr.	None	None	13.70%	25.30%

New Mexico	4 yr.	1 yr 75 and older	None	11.10%	10%
New York	5 yr.	None	None	13.30%	21.60%
North Carolina	5 yr.	None	People 60 and older are not required to parallel park in the road test. Vision screening is required every 8 yrs. for drivers 50 and older.	12.60%	17.10%
North Dakota	4 yr.	None	None	14.50%	13%
Ohio	4 yr.	None	None	13.40%	17.30%
Oklahoma	4 yr.	None	None that are safety related	13.60%	16%
Oregon	4 yr.	None	Vision screening is required every 8 yrs. for drivers 50 and older.	13.40%	16.60%
Pennsylvania	4 yr.	2 yrs 65 and older	None	15.90%	20.70%
Rhode Island	5 yr.	2 yrs 70 and older	None	15.80%	26.10%
South Carolina	5 yr.	None	None	12.10%	12.30%
South Dakota	5 yr.	None	None	14.50%	21.10%
Tennessee	5 yr.	None	None that are safety related	12.90%	17.10%
Texas	Effective 1/1/2002, 6yr staggered 4-6 yr. until then	None	None	10.20%	13%
Utah	5 yr.	None	Vision test required for people 65 and older	9%	11.80%
Vermont	4 yr.	None	None	12.20%	18.20%
Virginia	5 yr.	None	None	11.20%	16.10%
Wash.	4 yr.	None	None	11.60%	14.50%
West Virginia	5 yr.	None	None	15.20%	14.50%
Wisconsin	8 yr.	None	None	13.50%	16.90%
Wyoming	4 yr.	None	None	11.20%	13.30%
USA				**12.80%**	**16.90%**
CANADA				**12.40%**	**18.80%**

Sources: Insurance Institute for Highway Safety, “Licensing and Older Drivers” 2000; Central Intelligence Agency, “The World Fact Book,” 2000; National Highway Traffic Safety Administration, “Traffic Safety Facts 1996”; U.S Census Bureau, “1996 Population Estimates by Age and State”; International Road Federation, “World Road Statistics,” 1997; Statistics Canada, “Population by Sex and Age” 2000; Transport Canada, “Canadian Motor Vehicle Traffic Collision Statistics 1996, Persons Killed And Injured by Age Group” 2000.

Table 4 shows that 16 states have specific accelerated license renewal provisions for older drivers. Accelerated renewal procedures for drivers older than a specific age, usually 65 or 70, require in-person license renewal rather than electronic or mail renewal. (This accelerated renewal provision for older drivers exists in addition to varied license renewal procedures addressing physical or mental infirmities at any age.)

An additional issue to consider when assessing the significance of accelerated renewal provisions is variations in license renewal cycles for all drivers. As indicated Table 4, the length of license renewal for the general population ranges from 2 to 12 years. Thus, even though a particular state (Arizona, for example) has an accelerated renewal period for older drivers, the older drivers in a state that has a shorter renewal period for all drivers (Iowa, for example) will be forced to enter the renewal process much sooner. Studies assessing the effects of the accelerated renewal program on the rate of older drivers' crashes were not available.

Additional age-based renewal requirements exist for the District of Columbia, Illinois, and New Hampshire. In these three jurisdictions, behind-the-wheel road tests are mandatory for renewal applicants beyond a specified age.

Studies do not exhibit conclusive results for requiring behind the wheel testing on aging drivers. A 1996 study by McKnight and Lange found that in states requiring age-based testing, such as Indiana and Illinois, tested drivers were involved in 7 percent fewer crashes than their counterparts in the states of Ohio and Michigan. While age-based testing appeared to lower the crash rate for older drivers, it did not lower the proportion of single-vehicle crashes. The authors hypothesized that testing serves to induce less frequent driving rather than removing unsafe drivers from the roadways. Thus, they concluded that age-based road testing as a means of selectively removing unsafe drivers from the road receives no support from the comparisons made in their study (National Highway Transportation Safety Administration, 1997). As of December 3, 1998, Indiana removed the requirement that renewal applicants 75 and older were required to take a road test.

Medical Reporting Requirements

Medical reporting requirements for the licensing of older drivers is another approach that states and provinces have taken to address an increasing number of older drivers. Canada implements this strategy extensively. Seven out of the ten Canadian provinces require a medical report and vision tests for the license renewal of individuals above a certain age (Safe Mobility for Older Drivers, 2000). Alberta's medical reporting requires that a driver:

> . . . report any medical condition, change in health, or physical disability that may affect driving. Such reports must be made to Alberta Registries through a Registry Agent who will in turn inform Driver Records (Medical Review Board). This is 'the driver's' responsibility and legal obligation, not that of your doctor (Traffic Safety in Alberta, 2000).

The Alberta licensing requirements further mandate medical reports for older driver at much shorter intervals than for the general public. These can be as short as every two years after 75 years of age.

Some licensing agencies in the United States also have provisions for reporting medical conditions in the licensing and renewal process. Washington D.C. requires diabetics over age 70 to receive medical review board clearance prior to renewal. In the states of Utah, Oregon, North Carolina, and Maine, and in the District of Columbia, a vision test is required for individuals above a specific age. Statistics do not indicate that medical reporting requirements for licensing and renewal

of older drivers result in lower fatality rates for older drivers. Canada has medical reporting requirements for older drivers in all provinces, even though the crash fatality rate for the general population is lower than in the United States (Canada is .66 per 100 million kilometers driven, US is .95) (Bureau of Transportation Statistics, 1997). This trend does not hold true for older drivers. Even after accounting for a lower percentage of individuals over 65 (U.S. 12.8%, Canada 12.4%), Canadian drivers older than 65 still have a higher percentage of fatalities (Canada 18.8%, US 16.9%) (Transport Canada 1996, U.S Census Bureau. 1996, Statistics Canada 1996, Traffic Safety Facts 1996).

Studies do, however, indicate a correlation between medical conditions and crash rates. Findings of the study conducted by Salzberg and Moffat (1998) in the state of Washington confirm this claim, but more important, they imply that early detection of medical conditions combined with instituting driving limitations, can significantly reduce crash rates The researchers found a wide variety of medical conditions that have a significant impact on crash rates including dementia, cataracts, diabetes, glaucoma, foot abnormalities, falls, persistent back pain, cardiac conditions, bursitis, renal disease, and use of antidepressants. The finding on dementia was indicative of their findings in many of the medical conditions they studied: diagnosis and limitations in driving resulted in lower crash rates (National Highway Transportation Safety Administration, 1997).

Alzheimer's Disease is the most common form of dementia, with a prevalence estimated to be as high as 11.6 percent for those who are 65 and older and 47.8 percent of those who are over the age of 85 (National Highway Transportation Safety Administration, 1997). Older drivers with dementia whose driving was restricted showed a reduced collision and violation rate. This indicates that the testing, diagnosis, and limitation of driving privileges can create safer roadways for the entire population. (It should be noted that the reduced crash and violation rate was still approximately four times that of the general population.) Appendix 2 contains Salzberg's and Moffat's findings.

Some states (Utah, for example) have medical questions on the license application forms. A study conducted by Janke and Hersch (1997) found that although affirmative answers to questions are rare, an analysis of 579 license applications showing affirmative answers to health questions had significantly worse prior crash-involvement records than a randomly selected comparison group. The authors concluded that the medical impairment questions serve a beneficial traffic safety purpose (National Highway Transportation Safety Administration, 1997).

Referral Programs

A final licensing tool that states and provinces have implemented employs various referral programs for family members, doctors, judges, and police officers. These persons may notify a state licensing agency that a particular individual may be a dangerous driver.

The police are the most frequent users of referrals. Police reporting older driver crashes were the leading source of referrals (48 percent) followed by violations (44 percent). Observed behavior accounted for seven percent of the referrals and outside behavior accounted for only one percent (Safe Mobility for the Older Driver, 2000).

In Ohio, the court system, the police, and the Ohio State University Medical Center have come together in an attempt to assist older drivers. The Ohio State University Medical Center's Older Driver Evaluation Program has an agreement with municipal courts allowing judges and police to give the older adult an opportunity to undergo an evaluation as an alternative to formal charges for a motor vehicle violation. The evaluation assesses future driving ability and independence, and can result in shortening potential license suspension. Referred drivers complete a medical

profile, undergo tests of perceptual, cognitive, and psychomotor skills, and on-road driving skills. If, however, the driver refuses to participate, the ramifications of the refusal may include mandatory re-testing and conviction of the driving offense.

The other types of referral programs are for family and doctor referrals. Family referral programs were reported in 54 of the 60 the U.S states and Canadian provinces. Doctor referral programs were reported mandatory for only 11 of the 60 U.S. states and Canadian provinces (Safe Mobility for the Older Driver, 2000).

Alternative Transportation

Despite the legal efforts to protect elderly drivers from unnecessary risks associated with deteriorating health, other options are necessary to keep older Americans safely mobile. Alternative transportation opportunities are one possibility. The U.S. Department of Transportation acknowledges the existence of three non-driving mobility alternatives:

- Public Mass Transit Systems
- Informal Systems (Family and Neighbors)
- Community Based Systems

Public Mass Transit

According to the data provided by the American Public Transportation Association (1997), the existing network of public mass transit includes almost 6,000 providers who operate 13 modes of transportation, often with one provider offering more than one service.

Table 5
Number of Transit Agencies by Mode

MODE	NUMBER
Aerial Tramway	1
Automated Guideway Transit	6
Bus	2,250
Cable Car	1
Commuter Rail	18
Demand Response	5,214
Ferryboat [(b)]	25
Heavy Rail	14
Inclined Plane	5
Light Rail	22
Monorail	2
Trolleybus	5
Vanpool	55
TOTAL [(a)]	5,975

(a) Total is not sum of all modes since many agencies operate more than one mode.
(b) Excludes international, rural, rural interstate, island, and urban park ferries.
Source: American Public Transportation Association (1997)

The noticeable predominance of demand response services offered by transit agencies nationwide coincides with provisions of the 1990 Americans with Disabilities Act (ADA) and benefits elderly and disabled users. After losing the ability to drive, these users rely on public transportation as their only transportation method. ADA's Title II prohibits public transportation authorities from discrimination based on one's disability and mandates the implementation of the paratransit (demand response) system defined as "a service where individuals who are unable to use the regular transit system independently (because of a physical or mental impairment) are picked up and dropped off at their destinations" (U.S. Department of Justice, 1998). A case study from Eugene, Oregon, demonstrates how local authorities have implemented ADA requirements into the public transit system benefiting disabled and elderly who have no other alternatives.

Lane County, Oregon. The Lane Transit District operates the public bus transit system in Eugene and Springfield, two urban areas in Lane County. In compliance with ADA provisions, all 45 routes are fully accessible to individuals with any type of disability. Buses are capable of lowering the floor level to assist those who have trouble climbing steps and are equipped with lifts to load wheelchairs. In addition, each prospective user of the bus system can request a training session to familiarize himself or herself with the equipment. Apart from technical amenities, one innovative approach demonstrated by the LTD officials includes the implementation of the Bus Buddy Program. The program provides a one-on-one tutorial of bus usage for older individuals who, regardless of their disability status, want to become active users of the public transit system. The transit rider paired up with the volunteer is able to plan the trip as well as learn practical aspects of boarding and leaving the bus. Hoping to attract the elderly to the public transportation, LTD provides additional incentives, including Senior Ride Free Days, Special Senior Fares, and free rides for individuals over 80 years of age.

RideSource is LTD's ADA-mandated service, which operates in response to demand. Also known as a dial-the-ride system, it is available exclusively for those unable to use LTD's regular routes. An application required from each interested individual is used as the primary tool in determining eligibility and length of time the service may be provided. All qualified individuals willing to ride via RideSource between 5:30 a.m. and 11:30 p.m. during the week and from 8:00 a.m. to 8.30 p.m. on Sunday have to schedule the trip at least 24 hours in advance. Alternatively, if the trip takes place more than three times per week, during the same days and hours, and will be continued for the period of at least three months, subscription service can be arranged, which eliminates the need to schedule the ride. All vehicles provided by the system are capable of carrying wheelchairs and permit personal attendants to ride free of charge with the patron. "Curb-to-curb" service is provided as a "convenient way to make essential trips to the doctor or dentist, to go shopping and to travel to work, school, or recreational activities" (RideSource, 1996, p.1).

RideSource operates other alternative transportation services also, including:

- RideSource Escort: door-to-door service targeted to provide transportation to and from medical appointments for the elderly and disabled.
- RideSource Shopper: once-a-week trip to the area's grocery store via predetermined route. All individuals 60 or older can qualify, given they prove an inability to use LTD's fixed route system.

To fund the various services, the Lane Council of Governments (LCOG) contracts Special Mobility Services, a private, nonprofit company, to manage and operate RideSource. LCOG is responsible for the management of funds provided by LTD (via payroll tax levied within its service

area) and the State of Oregon's Special Transportation Fund, which is derived from a cigarette tax fund. According to David Braunschweiger, program manager for Special Mobility Services, LTD covers about 50 percent of actual costs of RideSource, which fluctuate around $15.50 per boarding per person. Consequently, with fares paid by the users ($1.50) covering only a fraction of operating costs, it may be necessary to rely on federal grants as an important alternative source of funding.

In conclusion, existing evidence suggests marginal popularity of public mass transit among the elderly. Of almost 8.6 billion trips taken via public mass transit in 1997, elderly customers have represented only 7 percent. According to the data provided by NuStats International (1997), more than 80 percent of the Madison Metro Transit System passengers were under the age of 45. Only about 3 percent of those using public transportation system in Madison are 65 years or older, despite the availability of lift-equipped buses and paratransit service, similar to what is used in Eugene, Oregon. The results of the Community Transportation Survey suggest that it may be reasonable to assume that the existence of a trend observed in Madison is not an uncommon phenomenon. Straight (1997), in a survey of 710 respondents 75 years or older, finds that almost three-quarters of all non-drivers cite inconvenience as a main reason for not using public transportation. Certainly, traveling by bus does involve planning ahead and requires adherence to posted schedules and timetables. Even a relatively short trip poses some degree of inconvenience and limits spontaneity commonly associated with traveling by car, making a shift to public transportation even more difficult. While a more demand-responsive system might improve the rate of ridership among the elderly, another problem hinted by Straight's study and associated with decreasing usage of public mass transit involves its lack of availability. Traditionally, public bus systems operate in urban areas, leaving residents of rural districts almost without any means of transportation. Considering the lack of available service with the increasing popularity of independent living choices made by elderly, it may be unrealistic to depend on public mass transit as a source of alternative transportation without much needed improvement in the overall design process or implementation of innovative programs such as Bus Buddies.

Informal Systems (Family and Neighbors)

Reliance on family and friends and other informal networks as means of alternative transportation rates relatively high among respondents of Straight's survey. Thirty-three percent of non-drivers unwilling or unable to use public transportation opted for this type of transportation. The popularity of informal systems on the local scale faces challenges in future years, because children willing to provide transportation for their parents may be in "short supply due to smaller family sizes, higher divorce rate, and greater proportion of women in the workplace" (U.S. Department of Transportation, 1997). Consequently, long-run design alternatives may have to exclude this form of transportation option for the elderly.

Community-Based System

Prohibitive characteristics of public mass transit systems and vulnerability of the informal network of friends and family may place greater importance on community-based system. Independent programs being implemented and operated within local communities with the help of volunteer and/or private, nonprofit organizations seem to offer the most flexible, cost-efficient, and affordable service for a maturing society. According to AARP (2000) even something as simple as an "informal group that provides a transportation 'pool' to help people get around … can make all the difference in helping others stay active and connected to their communities" (p.1). The follow-

ing sections present three community-based approaches working to provide efficient transportation alternatives at the most optimal level.

Portland, Maine. One of the most successful programs designed to provide alternative transportation to the elderly was initiated in Portland, Maine, by entrepreneur Katherine Freund. Since June 1997, Independent Transportation Network™ provides 24-hour transportation service for registered individuals within the city. Several innovative features utilized by ITN contribute to the popularity of the program among residents of Portland.

ITN's choice of passenger cars is not accidental. Cars are not only easier to enter and exit for the elderly, but small vehicles provide a personal, more welcoming atmosphere for the users. “When ITN vehicle arrives to pick up passengers, it looks and feels like a neighbor's or family member's car” (Freund, 2000, p. 6).

Individuals interested in using services provided by ITN have to complete an application (available by mail or on the World Wide Web at http://www.itninc.org/) and become registered members of the organization. Dues of $15 are collected yearly and allow members to enjoy a range of benefits including coupons, bonuses, and incentives for the referral of additional customers. According to Freund (2000), this special "feeling of ownership and belonging" helps elderly patrons to overcome stress associated with the loss of driving privileges.

The fee schedule for a particular trip is based on the distance traveled, the number of riders, and the requested time. Requests “on demand” are more expensive than the ones received with at least 24-hour notice. The most expensive per-mile charge ($1.50) would be assessed to the individual riding alone and requesting immediate transportation, while a scheduled trip for four would cost each individual only 30¢ per mile. In addition to per-mile charges, other miscellaneous fees include a pick-up charge of $2.00 (during the day) and $5.00 (before 7.00 a.m. and after 9.00 p.m.), and a stop charge of $1.00 per stop. Based on the data presented by Freund (2000), almost 97 percent of rides receive advance scheduling with a significant number of members willing to share their ride, which further discounts the fare. The estimated average round trip for daytime rides is three miles with an $11.00 per-trip per-person fare. Another important step in emphasizing a non-commercial and more family-like approach of the service includes an elaborate debit system used to collect fares for each ride. No cash is exchanged on board ITN's vehicles; rather each member is billed to his or her prepaid account and receives a monthly statement showing all trips made and fees due for the last period.

Involvement of the local community proves crucial for successful operation of the ITN network, which includes reducing the operating costs and expenditures. A well-managed network of volunteers supplies about 30 percent of all drivers employed by the system. The development of the Ride & Shop program allows local businesses to cover a fraction of the costs ITN members would have to pay to travel to and from the participating store. Similarly, the Healthy Miles program involves local health care providers who subsidize the cost of a trip to the hospital or clinic. The combined efforts of the community provide about 80 percent of funds needed to cover operating costs, with the remainder supplied by the federal and state grants.

Well-documented and consistent growth among registered users of the Independent Transportation Network, along with growing revenue streams, confirm a successful alternative transportation system for older persons in Portland. The accomplishments of the program do not stop there, however. Under the Federal Transit Administration deployment grant the ITN is obligated “to develop an economically sustainable model, suitable for replication on other communities” (Freund, 2000). To achieve this directive, a three-phase ITN Work Plan has been designed to concentrate on

areas including providing services to rural areas, replicating the methodology, and sustaining the economic health of the system. According to the founders, the project is on schedule with the anticipated completion by the end of 2001. At that time communities across the nation could utilize the ideas originated by ITN in Portland.

Wichita, Kansas. Sedgwick County Transportation Brokerage (SCTB) represents another community-based approach to providing alternative transportation to the elderly. Initiated in December 1998, the system consists of a comprehensive network of companies specializing in transportation of elderly, disabled, and ill. The chosen approach was a direct response to the findings of a study conducted by the State Department of Aging. The research revealed the unavailability of a dependable service, high cost of the rides that were available, and general confusion about whom to contact with a transportation request. SCTB was able to remedy the problem with the following actions:

1. Efficiently assess transportation needs of the elderly, ill, and disabled and match them with the appropriate transportation company;
2. Complete a compendium of vendors willing to operate around the clock, seven days per week, and provide most flexible service for both the residents of Wichita as well as the rural area of Sedgwick County;
3. Secure funds used for fare subsidy and use them efficiently to minimize both operating costs and the costs imposed on the riders.

As of December 1999 approximately 2,300 applicants have actively participated in the system. The reservation process(wherein reservations are taken 24 hours in advance and during normal business hours) is used to assess the transportation needs of a particular customer, to match the customer with the available vendor, and to address any special requests, including wheelchair availability and “door-to-door” service. The highly centralized design of the SCTB has allowed for efficient management of financial resources. Because of the wide spectrum of individuals served by the SCTB, there was a potential to seek funding from several agencies, including state and federal sources, aimed at helping only a specific group, such as the disabled or mentally ill. Under the previous system, it often meant “funds tied to the vehicle” requiring “a consumer [to call] several different transportation agencies in order to get the ride … which has the funding based on the passenger’s age or disability status, trip purpose, requested destination” (Harmon, 2000, p. 2).

Now, the organized database of all users allows for efficient retrieval and channeling of funds at the moment the request for the ride is made. The cost of the ride is determined instantaneously based on the existing subsidy and the availability of vendors participating in a particular program. Some grants, which have been secured by the SCTB, require no co-payment from the rider, while others call for a flat rate or a fee based on the rider’s income. The design of the system has permitted many users to reduce their out-of -pocket expenses without complicated procedures and lengthy paperwork.

Columbia, Missouri. A somewhat larger community based alternative transportation program is run by OATS, Inc., established in 1971. Its continuous growth has currently allowed OATS to respond to the transportation needs of almost 30,000 residents with a fleet of 465 vehicles and continuous help of 468 employees and more than 1,000 volunteers. According to its annual report (1999) and Executive Director Linda Yaeger, the company’s eight satellite offices are dispersed throughout the state of Missouri to address inadequate mobility options for disabled, sick, and elderly who live in remote areas. Each office is responsible for the efficient handling of passengers’ requests and van dispatch. Reservations from registered users are taken during regular business

hours (8 a.m. to 5 p.m.) for the rides between 6 a.m. and 6 p.m. Under special circumstances, the dispatcher can allow for the transport to be arranged beyond the standard hours of operation.

The regional centralization has had profound effects on cost-saving strategies, allowing the company to achieve an average operating cost of only 90¢ per mile. This is especially important as almost all rides are provided on the "contribution only" basis. That is, there is no required fee, but each vehicle is equipped with a sign stating suggested donation amounts, depending on the purpose of the trip. Of almost $10 million budgeted for spending in 1999, only 4 percent is derived from riders' contributions. The majority of financial resources acquired by OATS come from federal and state grants requiring more careful financial planning given fragility of funds and costs of operating the company successfully.

Recommendations

Our recommendations are organized in three sections. Each section describes specific comments based on our analysis.

Transportation System Design Standards and Practices

Our research in this area has indicated various problems with sign perception and understanding. Particular design practices used in intersection and highway construction seem to overestimate the overall perception reaction times actually demonstrated by the elderly, leading to an increased crash rates in those places. To respond to a growing population of elderly drivers, the following steps should be taken to minimize the chance of crashes due to various design inadequacies.

Traffic control devices, including signs, should consistently be made larger. Small or illegible text should be removed, and greater emphasis should be placed on symbols that are placed in greater distance from each other. Because of the considerable costs associated with sign replacement, implementation can be spread over a number of years. More user-friendly geometric design ought to diminish crash rates associated with faulty intersection design, in particular for sharp left turns. Implied costs of this recommendation may be diminished if all appropriate improvements are undertaken during periodic scheduled road maintenance. Finally, greater consistency in design and cooperation among agencies in incorporating new research findings into actual projects can significantly reduce the confusion that elderly drivers experience.

Alternative Licensing Practices

We conclude that alternative licensing procedures may have limited effectiveness in lowering the crash and fatality rates of older drivers. Many states have attempted to restrict license renewal periods, but no conclusive evidence could be found to confirm the connection between shorter renewal cycles and lower crash rates. On the other hand, studies show that a higher percentage of older drivers involved in crashes are afflicted with some form of impairing medical condition. Consequently, the best alternative procedure that we can recommend is greater use of medical reporting and questioning strategies during the licensing process. Requiring adequate corrective measures based upon medical reporting and granting (or extending) driving privileges only to persons who do not have significant health problems may be the most effective approach.

Alternative Transportation Opportunities

Alternative Transportation opportunities are a key ingredient in keeping aging Americans safely mobile. As indicated in the Community Transportation Survey, 75 percent of non-drivers cite inconvenience as the main reason for not using public transportation. The three community-based transportation systems analyzed in this paper serve as an example of how to provide more responsive and user-friendly transportation options for elderly.

The transportation system available to older drivers in Portland, Maine, provides an effective public-private source of reliable transportation with a particular emphasis on creating a more family-like atmosphere. The use of cars is an important part of success of this program—for two reasons. First, cars are more comfortable for seniors to access. Second, the cars in this system are not distinctly marked and provide feeling to seniors that they are being picked up by family or friends. Yearly membership fees serve an important role of providing an important sense or "ownership" to individuals using the system.

On the downside, the implementation of the programs such as ITN (Independent Transportation Network) may impose considerable financial burden on the local administration willing to replicate the system, especially during the early years. The reliance on the existing public transportation system, while proving not to be effective, may thus be the only option, at least in the short run. To help overcome the adverse reaction to the mass transit systems, innovative programs may have to be implemented. The Lane Transit Authority in Eugene, Oregon, provides one such effective approach. The "bus buddy" system in this city allows older users to request a welcoming and helpful individual to assist them in acclimating to the public transportation system, making the bus an effective form of transportation instead of a feared unknown.

References

Alicandri, Elizabeth. (1994). *Highways Older Drivers Can Use.* Presented at the May 1994 American Society of Civil Engineers Conference, "Innovations in Highway Safety – A Broad Perspective."

American Association of Retired Persons. (2000). *Transportation: Independent Living Kit* [online]. Retrieved March 2, 2000, from the World Wide Web: http://www.aarp.org/programs/connect/transportation.html

American Association of Retired Persons. (2000). *Community Transportation Survey – Executive Summary.* [online]. Retrieved March 2, 2000 from the World Wide Web: http://reseaerch.aarp.org/il/d16603_commtran_1.html.

American Association of Retired Persons, Public Policy Institute (2000). Retrieved March 7, 2000, from the World Wide Web: http://research.aarp.org/consume/fs51r_older_drivers.html.

American Association of Highway and Transportation Officials (AASHTO). (2000). [online]. General information retrieved March 16, 2000, from the World Wide Web: http://www.aashto.org.

American Public Transportation Association. (1997). General Summary [online]. Retrieved April 15, 2000, from the World Wide Web: http://www.apta.com/stats/summary/index.htm

Benekohal, Rahim; Michaels, Richard; Shim, Eunjai & Resende, Paulo. (1997). *Effects of Aging on Older Drivers' Travel Characteristics.* Transportation Research Record, Number 1438. 1997

Black, William R. (2000) *Social and Economic Factors in Transportation*, presented at the Annual Meeting of the Transportation Research Board, January 2000. Committee on Social and Economic Factors in Transportation.

Bureau of Transportation Statistics (1997) *"National Transportation Statistics."* Retrieved April 3, 2000 from the World Wide Web: http://www.bts.gov/

Carr, David B. (2000). *The Older Adult Driver*. American Family Physician, Volume 61. January 1, 2000. Pages 141-46.

Charness, Neil, and Elizabeth A. Bosman. 1992. "Human factors and age." In F. I. M. Craik and T. A. Salthouse (Eds.), The Handbook of Aging and Cognition. New Jersey: Lawrence Erlbaum Associates, pp. 495-549.

Central Intelligence Agency. (1996). *"The World Factbook"*

Crary, Dick. (1999). *Old and On the Road*, ABC News.com, November 22, 1999. Retrieved March 16, 2000, from the World Wide Web: http://www.abcnews.go.com/sections/living/ Daily-News/elderlydrivers991122.html.

Dewar, Robert E.; Kline, Donald; and H. Allen Swanson. (1994) *Age Differences in the Comprehension of Traffic Sign Symbols*. Presented at the Transportation Research Board Annual Meeting.

Federal Highway Administration (FHWA) (1994) FHWA-RD-94-021. *Accident Analysis of Older Drivers at Intersections.* Turner Fairbanks Highway Transportation Research Center, 1994.

Federal Highway Administration (FHWA) (1994) FHWA-RD-94-069. *Symbol Signing for Older Drivers.* Turner Fairbanks Highway Transportation Research Center, 1994.

Federal Highway Administration (FHWA) (1995) FHWA-RD-95-129 *Improvements in Symbol Sign Design to Aid Older Drivers.* Turner Fairbanks Highway Transportation Research Center, 1995.

Federal Highway Administration (FHWA) (1997) FHWA-RD-97-001. *Analysis of Older Drivers on Freeways.* Turner Fairbanks Highway Transportation Research Center, 1997.

Freund, K. (2000). Independent Transportation Network™ : Alternative Transportation for the elderly. TR News, 206, 1-12.

Harmon, V. (2000). *NACo Achievement Award Application*. Wichita, Kan. Copy supplied by the author.

Insurance Institute for Highway Safety (2000) *Licensing Renewal, Older Drivers,* Retrieved April 3, 2000, from the World Wide Web: http://www.highwaysafety.org/safety_facts /state_law/oldeer_drivers.htm

International Road Federation. (1997). *World Road Statistics*.

McGwin, G., Brown, D.B. (1999*).* Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention*, Vol. 31, No. 3, pp. 181-98.

National Highway Transportation Administration. (1997). *Safe Mobility for Older Driver,* Retrieved April 3, 2000, from the World Wide Web: http://www.nhtsa.gov/search97cgi_cgi/s97_cgi.exe

National Highway Traffic Safety Administration. (1996). *Traffic Safety Facts 1996, Chapter 5 States.* Retrieved April 3, 2000 from the World Wide Web: http://www.nhtsa.dot.gov/people/ncsa/pdf/TSF96_5.pdf

National Highway Traffic Safety Administration (1997). *Safe Mobility for Older Drivers*. Retrieved April 3, 2000 from the World Wide Web http://www.nhtsa.gov/search97cgi_cgi/s97_cgi.exe

National Highway Traffic Safety Administration (1998) *Traffic Safety Facts 1998, "Older Population."* National Center for Statistics and Analysis. Washington, D.C.

National Highway Transportation Safety Administration (1989). *Safe Mobility for Older Drivers*, Retrieved April 3, 2000, from the World Wide Web: http://www.nhtsa.dot.gov/people/injury/olddrive/safe/01a.htm

NuStats International. (1997). *Madison Metro Transit On-Board Survey Spring 1997*. Austin, Texas Copy supplied to authors.

Paniati, Jeffrey. (1994). Program Manager. Turner Fairbanks Highway Research Center. U.S. Department of Transportation. Highway Safety Information System Report. [online] Retrieved March 2, 2000, from the World Wide Web: http://www.tfhrc.gov/hsis/94-021.htm.

RideSource. (1996). *RideGuide*. Eugene, Ore.: Copy supplied to author.

National Highway Transportation Administration. (1998) *Safe Mobility for Older Drivers*, Retrieved April 3, 2000, from World Wide Web: http://www.nhtsa.dot.gov/people/injury/olddrive/safe/01a.htm

Statistics Canada, *Population by Sex and Age*, Downloaded from the World Wide Web:http://www.statcan.ca/english/Pgdb/People/Population/demo10a.htm

Straight, A. (1997). *Community Transportation Survey* [online]. Retrieved March 28, 2000, from the World Wide Web: http://research.aarp.org/il/d16603_commtran_1.html

Suen, S. Ling and C.G.B. Mitchell (2000). *Accessible Transportation and Mobility*. Transportation Research Board, Annual Meeting 2000. Committee on Accessible Transportation and Mobility.

Traffic Safety in Alberta. (2000). Downloaded April 3, 2000 from the World Wide Web: http://www.saferoads.com/drivers/drivers/aging.html

Transportation Development Centre. (1998). *The Potential of Intelligent Transportation Systems to Increase Accessibility to Transport for Elderly and Disabled People* (TP 12926E) [online] http://www.tc.gc.ca/tdc/summary

Transport Canada. Retrieved March 16, 2000, from the World Wide Web: http://www.tc.gc.ca/tdc/suimmary/12926e.htm.

Transport Canada, *Canadian Motor Vehicle Traffic Collision Statistics 1996, Persons Killed And Injured by Age Group* Retrieved from the World Wide Web: http://www.tc.gc.ca/roadsafety/STATS/stats96/st96agee.htm

U.S Census Bureau. (1996). *1996 Population Estimates by Age and State.* Retrieved from World Wide Web: http://www.census.gov/datamap/www/index.html

U.S. Department of Justice. *(1998). A Guide to Disability Rights Law* [online]. Retrieved April 16, 2000, from the World Wide Web: http://www.usdoj.gov/crt/ada/cguide.htm

U.S. Department of Transportation. (1997). *Improving transportation for a maturing society. Report of the Departmental Steering Committee* [online]. Retrieved March 1, 2000 from the World Wide Web: http://ostpxweb.dot.gov/policy/aging/Index2.HTM

Wisconsin DOT. (1999). *1998 Wisconsin Traffic Crash Facts*. Madison, WI. Copy supplied by the author.

Yaeger, L. (2000). *OATS, Inc. 1999 Annual Report*. Columbia, Mo. Copy supplied to the authors.

Appendix 1: Signs and Symbols, Manual of Uniform Traffic Control Devices (MUTCD)

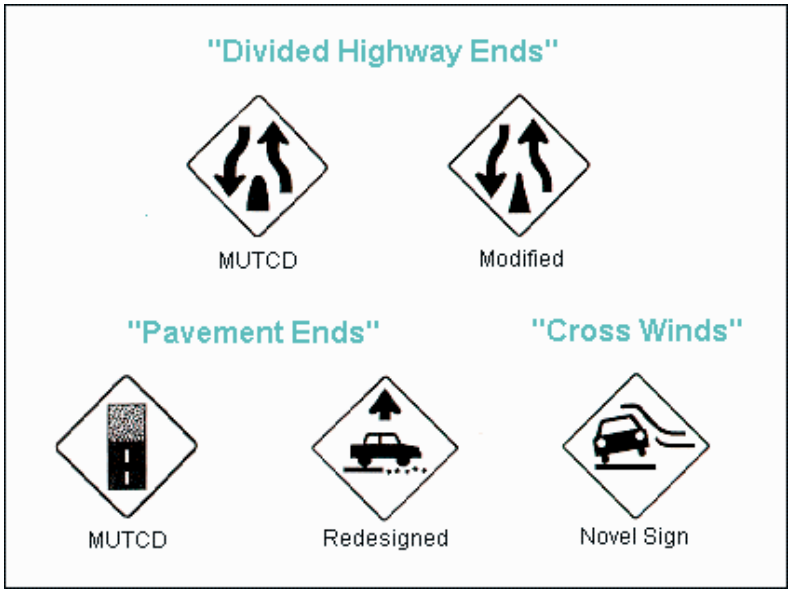

Figure 1. Examples of symbol sign alternatives studied.

Sign Name	MUTCD Number	Recognition Distance (m) Improved	Standard	Percent Increase
Modified				
Cross Road	W2-1	467	299	56
Right Curve	W1-2R	291	269	8
Hospital	D9-2	265	202	32
Divided Highway Ends	W6-2	206	178	16
Keep Right	R4-7	202	181	12
No Parking	R8-3a	120	116	4
Redesigned				
Advance Flagger	W20-7a	192	173	11
Pavement Ends	W8-3a	107	75	43
Campfire	RA-030	99	80	24
Ranger Station	RG-170	73	58	26
Seat Belt	R16-1	67	57	19
Novel				
Crosswind	None	114		
Horse-Drawn Vehicle	None	108		
Reduced Visibility	None	110		
Truck Entrance	None	96		
School Bus Stop Ahead	None	84		

Table 1. Summary of recognition distance improvements for modified, redesigned and novel designs.

Source: Turner Fairbanks Transportation Research Center, Federal Highway Administration

Appendix 2

Driving Records (number of incidents per 100 drivers per year) for Control Group Drivers and Drivers and Drivers with Medical Conditions Who Were Required To Take a Special Driving Exam

	Pre-Exam Rate Collision Rate	Post Exam Collision Rate	Pre-Exam Violation Rate	Post Exam Violation Rate
Control (n=449)	3.818	1.165	7.5087	2.2614
All conditions: Failed Exam (n=69)	12.4224	0	15.735	0
All conditions: Passed Exam (n=380)	7.0677	3.289	13.3835	5.2632
Cataracts (passed exam; n=45)	5.0794	2.0513	15.2381	2.0513
Diabetic Retinopathy (passed exam n=14)	12.2449	0	8.1633	2.1978
Macular Degeneration (passed exam; n=71)	3.2193	3.467	6.4386	5.2004
Diabetes Mellitus (passed exam: n=71)	6.3492	1.1396	8.4656	2.2792
Cardiovascular Conditions (passed exam; n=47)	7.2948	1.964	20.6687	2.6187
Neurological Condition (passed exam: n=20)	8.5714	3.0769	17.1429	7.6923
Psychiatric Conditions (passed exam n=46)	12.4224	4.6823	23.6025	8.0268
Stroke/Cerebral Vascular Conditions passed exam: (n=21)	5.4422	4.3956	8.1633	7.326

Excerpted From: Salzberg and Moffat, 1998 Washington State Department of Licensing Special Exam Program- An Evaluation

Note: For comparison purposes, in Washington State during 1996, there were 140,215 total collisions and 4,037,543 licensed drivers yielding a rate of 3.47 collisions per collisions per 100 licensed drivers during this one-year period.