Improving Transportation for a Maturing Society

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Improving Transportation

for a

Maturing Society

U.S. Department of Transportation

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Preface

In December 1995, Secretary of Transportation Federico Peña asked for a long-range overview and a preliminary, proactive Department-wide strategy to accommodate the growing cohort of older adults that will be providers and consumers of transportation in the twenty-first century. This overview was to encompass the perspective of older adults in all transportation modes, operating commercially as well as privately.

The Operating Administrations of the Department have for years been actively working to support the safety and mobility needs of older adults. Their programs and the extensive information collected by them provided a broad base upon which to conduct this overview.

This report is based on reviews of the literature and ongoing Departmental programs, and on input from five expert panels. The panels covered *Demographic Scenarios of Aging in the U.S., the Human Factors of Aging, Alternatives for Personal Transportation, Medical Considerations in Aging,* and *Management Practices and the Older Transportation Worker*. We would like to thank the members for making the time to join the expert panels and we are especially grateful for the time and extra efforts of those panel participants who served as host or discussion leader for them. The panel participants are listed in Appendix D-I of this report.

The overview was guided primarily by a Departmental Steering Committee on which all modes were represented. The conclusions that emerged out of the deliberations of the committee are reflected in the following material. Of particular emphasis was the planning strategy of assuring safe mobility for older adults. In this work, the Department has identified a set of possible responses to the impending demographic shift, as baby boomers begin to swell the ranks of the elderly in the next century.

This document begins with the demographic setting by which future transportation problems must be viewed. It includes a detailed description of the aging process and the medical issues which should be of concern for older adults in all modes. It then reviews the issue of safety, including crash involvement of older operators, and the risk management systems that have evolved in each commercial mode. The next section moves into the area of lifelong mobility, and examines what can be done to keep older adults safely mobile, including the provision of non-driver alternatives, countermeasures for the fragility of older adults, and what can be done with new technology to add to the years over which older adults can continue to operate independently and safely. There are unsafe drivers in all age categories, and the report details the programs to identify and evaluate the problems particular to older drivers, and what can be done to help them. The report also discusses such issues as mobility and the quality of life, and personal security.

In each area, the issues are briefly summarized, and a number of remedial proposals are offered for consideration. These initiatives were developed from the proceedings of several groups, including the five Expert Panels, the Steering Committee, and the previous work of the Department. Most of the proposals build on ongoing Departmental and other Federal, state and private sector activities.

We wish to thank all those who made contributions to this report. This work was the product of the joint efforts of many people: the expert panelists and the Steering Committee as just noted, but also the staff of the Safety Division in the Office of the Assistant Secretary for Transportation Policy, and the Volpe Center. The names of all participants appear in Appendix D of this report.

Departmental Steering Committee
(in alphabetical order):

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Bert Arrillage	Federal Transit Administration
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John Eberhard	National Highway Traffic Safety Administration
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Harold Lunenfeld	Federal Highway Administration
Truman Mast	Federal Highway Administration
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EXECUTIVE SUMMARY

BACKGROUND

The older adult population (defined here as those over 65) increased in the United States eleven-fold during this century compared to a threefold increase for those under 65. We are all aware that Americans are living longer and many of us can look forward to 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, will grow to 36.2 million by 2005. By the year 2020 it will be 53.2 million, or 16.5 percent of the population. This population aging will impact all aspects of our society and represents a unique challenge to the community of transportation officials. The actions we can take now to prepare for this change will have a profound effect on the lives of future older Americans.

The Department of Transportation (DOT) has for years been extensively engaged in work to support the safety and mobility needs of older adults. The National Highway Traffic Safety Administration (NHTSA) has had an older driver program since 1988. The Federal Highway Administration (FHWA) embarked on a major program in 1989 for improving highway travel for an aging population. Federal Transit Administration (FTA) grant programs for older adults and persons with disabilities for rural transportation, and for paratransit, all provide benefits to older adults. Additional details on these programs are found below and in Appendix A of this report.

In December 1995, Secretary Peña directed the Department to develop a long range overview, and draw up a preliminary, proactive strategy to determine the actions needed to accommodate the growing cohort of older adults who will be transportation providers and consumers in the 21st century. This overview was to encompass the perspective of older adults in all modes, operating commercially and privately. A full report on the issues analyzed, and some of the recommendations of the five expert panels that were convened follows. Specific recommendations, relative priorities, and budget estimates that would be part of a definitive long term strategic plan are the next step. The following elaborates on issues of safety and mobility, and then describes a number of components that would be integral to formulating such a plan.

SAFETY

The aging process affects individuals in many ways, resulting in a broad range of capabilities and extensive differences among older adults. The increased incidence of disease and decline in capabilities, that are part of the normal aging process, gradually impair the cognitive, sensory, or psychomotor capabilities needed for the operation of all transportation vehicles. Some diseases, such as strokes, cause sudden impairments. Generally, however, there is a slow decline of capabilities, at rates that vary widely among individuals. Most people, as their capacities diminish, withdraw gradually and responsibly from operating vehicles. Consequently, there is not at present a sufficient number of crashes associated with older users and operators to define a serious safety problem, although the changing demographics could lead to serious problems in the decades ahead.

Automobile Drivers - The perception of an older driver safety problem comes about when the crash and fatality rates per mile driven are examined. The fatality rate per 100 million vehicle miles traveled stays reasonably level for drivers up to age 75, and then begins to rise, climbing steeply for persons over 80.[1] The much higher fatality rate for those over 80 is partly attributable to their greater fragility, compared with younger persons.

By 2020 there will be an additional 20 million more older adults in the population. Of particular concern are those aged 75 and above, and applying today's fatality rates to that group indicates that for them, traffic deaths could increase 45 percent (and possibly higher based on other trends), unless the efforts of the safety community can dramatically lower their crash rate or increase their crash protection.

Pedestrians - The safety of older pedestrians presents a significant challenge to the Department. Pedestrians aged 70 and over represented almost 9 percent of the population, but accounted for 19 percent of all pedestrian fatalities in 1994. The fatality rate for this group was higher than for any other age group -- 4.36 per 100,000 (vs. 2.1 for the overall population).

Commercial Operators - Older operators of trucks, buses, general aviation airplanes or ships do not appear to present a significant safety problem at this time. Typically, they maintain their performance levels by using their experience, automation of some activities, streamlining of tasks, and accommodation. The vast majority of older commercial operators retire responsibly, before medical conditions or diminishing capacities become an issue.

SAFE MOBILITY, FOR LIFE

One vibrant force in this country is its high degree of personal mobility. Most of us are conditioned to go where we please, how we please, on our own schedule. This is part and parcel of the quality of American life. We now have more cars than licensed drivers, more than 11.4 million documented watercraft, and 170,000 airplanes, all for personal mobility (necessity or recreation) in one form or another.

Except for persons living in our largest cities, and those with low incomes, the primary constraint on full mobility in the personal lives of most Americans comes with the erosion of the capacities necessary for the safe operation of a vehicle. There comes a time for most older adults when a difficult adjustment must be made, to find alternative means to get to such necessary destinations as grocery stores, medical appointments, places of worship, family, and social engagements. If safe, affordable mobility alternatives are not available, as can often be the case for those who retire to or live in rural areas or the outlying suburbs, the quality of life is clearly diminished.

It is in the national interest to keep people operating their personal vehicles as late in years as possible for quality of life reasons; yet we do not want that operation to unnecessarily endanger the individual or the public. It is also in the public interest to maintain the productivity and value

1. See Figures 3 and 4 in the main text.

added to our national economy of those older adults who operate vehicles commercially, as long as it is safe, yet we must recognize that more stringent screening and evaluating measures have been required to account for the higher public risks presented by those operating commercial vehicles.

These three policy objectives: safety, individual personal mobility, and facilitating the eventual transition to mobility alternatives define a strategic planning goal for the Nation's transportation system, ***Safe Mobility, For Life***. This would be achieved through new extensions of the department's research, and improved coordination of funds and programs already available at the state and community level. The following precepts would characterize this goal:
1.) keep people operating cars as late in life as possible, as long as they can do so safely;
2.) promote technology and training that support those with functional or cognitive deficits so they can continue to operate vehicles safely; 3.) improve screening and evaluation techniques to detect when people should no longer be operating; 4.) bring new emphasis to the provision of non-driving alternatives for older adult transportation needs; and 5.) educate the public on how to maintain safety and what to prepare for in older age.

A proposed series of Departmental initiatives that could contribute to this goal are outlined below. They must be added to a selected set of ongoing programs, that should continue to receive enhanced priority.

RECOMMENDED NEW INITIATIVES

The following initiatives are needed to assure that the whole spectrum of concerns for older adults are comprehensively addressed.

<u>Added Emphasis on Mobility Alternatives for Older Adults</u> - Mobility for older adults should be integrated into planning at all levels: individual, community, state and Federal. At the community level, metropolitan planning organizations (MPO) and state planning agencies should consider the special needs of older adults. The following actions are proposed:

- Inventory best planning practices to assure mobility alternatives for older adults.

- Evaluate the most effective mobility services and systems, and provide the means to stimulate their replication.

- Better coordinate Departmental and other Federal efforts by upgrading the DOT/HHS Coordinating Council on Human Services Transportation.

- Increase the focus of the FTA Technical Assistance program to improve mobility alternatives for older adults.

- Use the ISTEA reauthorization process to assure planning for the mobility of older adults.

- Enlarge powers for DOT and HHS Secretaries to grant waivers and exceptions for funding community providers, where they would lead to more cost effective transportation service and higher system use rates.

Countermeasures for Fragility of Older Adults - Place new emphasis on research to develop countermeasures to compensate for the fragility of older adults, recognizing the growing level of older adult injuries and fatalities expected over the next 25 years.

Develop Medical Practice Parameters and Guidelines - Develop a set of guidelines and training modules for use by physicians and health care professionals as an authoritative source when conducting evaluations required for commercial licensure, as well as personal licenses in instances where medical examinations are required.

Policy Studies - Initiate selected studies to support public policy decisions, covering such areas as Security in Transportation, Linkage of Mobility to Health Care Costs, Influence of Mobility Alternatives on Driver Cessation, and research to improve our understanding of the effects of certain medical conditions, functional disabilities, and behavioral limitations on operator performance and crash involvement.

CURRENT PROGRAMS RECOMMENDED FOR ENHANCED PRIORITY

The Department has had effective, even exemplary, programs underway for many years designed to accommodate and support the increasing number of older adults expected within the system. Some of those which merit continued high priority are:

Improving Highway Travel For an Aging Population - To be ready well in advance for the coming influx of older drivers, FHWA established a high priority research program in 1989 dedicated to improving travel for an aging population. While research continues, much useful information is now available and the results will be compiled soon into a ***Preliminary Older Driver and Highway Safety Handbook*** for distribution to highway engineers and community planners.

Improving Our Identification and Evaluation Systems - Today most problem drivers are identified somewhat haphazardly and belatedly by their crash experience, their traffic citations, reporting by physician, police or family, and their license renewal applications. NHTSA has under development improved identification techniques and new tests focusing on disabilities prevalent in older adults. It also has a research program underway designed to help the states determine who should and should not be driving. Built into the development is an extensive series of field tests to help ensure that older adults are not being discriminated against by the proposed measures.

Technology - Many performance-aiding technologies will become available over the next 10 to 20 years to enhance the safety and ease of operating vehicles, and thus directly support older operators. Development and introduction of these new technologies in all modes is being

supported by DOT and other agencies, and also private organizations, many under the Intelligent Transportation Systems (ITS) program.

Some of the emerging technologies which hold the greatest promise for improving the safety and mobility of older users are: Collision Warning/Avoidance Systems (detection of objects and people in the path of the vehicle); In-Vehicle Signing (providing advance notice in the vehicle of caution, speed change, and contour signs that will shortly be encountered); Incident Identification and Location Systems (Mayday rescue systems that automatically alert authorities of the location of a vehicle experiencing emergencies); Rural Public Transportation Information Systems (customer paging systems, combined with vehicle location and tracking systems, to provide real-time, demand-responsive services); and various simulator applications (to assist in screening, evaluation, and training older adults to use new technologies, as well as to assist in establishing test requirements or developing new driving aids).

CONCLUSIONS

Secretary Peña, concerned about the quality of life of the growing older population, initiated a comprehensive, forward looking overview of what improvements must be made to accommodate the changing demographic demands on the Nation's transportation system. These demographics will find us with a large population of older operators, who are more widely dispersed, and more accustomed to full mobility. Safety problems for older adults are anticipated in some areas and warrant continued attention. The effectiveness and productivity of our testing, evaluation and rehabilitation programs need to be improved. Countermeasures need to be developed to deal with the fragility and higher fatality rate of older adults. New forms of mobility alternatives need to be developed and tested. This will be an ongoing process, requiring continuous monitoring and innovative policy making. How the Department meets this challenge can have far ranging impacts on the quality of life for today's older adults and ultimately all of us.

1. OUR MATURING SOCIETY

1.1 OLDER ADULT POPULATION

The number of older adults[2] in the population has increased eleven-fold during this century as compared to only a three-fold increase for those under 65 years of age. The U. S. Census indicates that older adults numbered 33.5 million, or 12.8 percent of the population in 1995. This age group will total 36.2 million by the year 2005 and 53.2 million, or 16.5 percent of the population, by 2020. By 2030, 1 in 5 Americans will be an older adult.[3]

This past growth, and the forecast of a continuing increase, is due to reductions in mortality rates; the improved chances of survival at the very end of the age spectrum (the 'longevity boom'); decreases in the birth rate lowering the influx of younger people; and the size of the "baby boom" (those who were born between 1946 and 1964).[4] Figure 1 and Table 1 show the actual and projected growth of the U.S. population by age categories.

We are all aware that Americans are living longer. Many can expect an extended period of health and activity beyond age 80. Life expectancy has increased 28 years since 1900 [5]. Because the span of the remaining expected life for older adults is increasing, the U. S. Census now subdivides that sub-population into three segments: (1) the 'young old' (65 to 74 years); (2) the 'aged' (75 to 84 years); and (3) the 'oldest old' (85 years and over). [6] Currently, the population aged 85 and over is the fastest growing of the older population segments. It will continue to grow for the rest of this century.[7]

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2. The definition of an older adult used in this paper is anyone 65 years of age or older to conform to common practice in Social Security, the Census, etc.

3. U. S. Bureau of the Census. Current Population Reports. Special Studies. P23-190, *65+ in the United States.* U.S. Government Printing Office, Washington, DC, 1996. p. 2-1.

4. U. S. Bureau of the Census, 1996. p. 2-2.

5. Dychtwald, Ken and Joe Flower. Age Wave. The Challenges and Opportunities of an Aging America. Los Angeles: Jeremy P. Tarcher, p. 6.

6. U. S. Bureau of the Census, 1996. p. 1-1.

7. U. S. Bureau of the Census, 1996. p. 2-8.

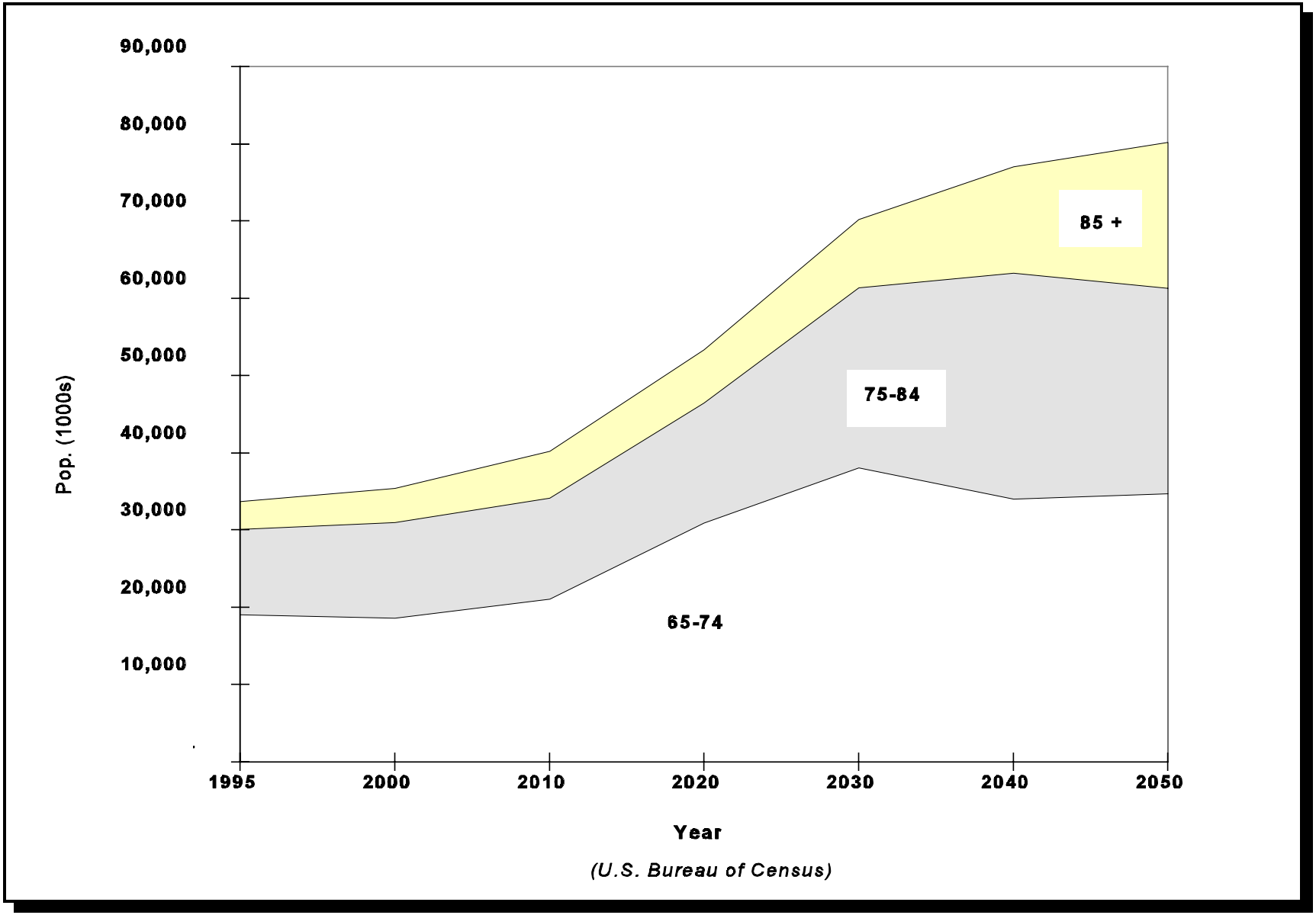

Figure 1. Population Projections for U.S. Residents

Table 1. Resident Population Projection by age (1995-2050)

year	all ages	45-54	55-64	65-74	75-84	85 +	65+	75 +
1995	263,434	30,224	21,241	18,963	11,087	3,598	33,648	14,685
2000	276,241	36,170	23,690	18,551	12,438	4,333	35,322	16,771
2010	300,431	44,099	34,552	20,978	13,157	5,969	40,104	19,126
2020	325,942	38,885	42,262	30,910	15,480	6,959	53,349	22,439
2030	349,993	38,936	37,429	37,984	23,348	8,843	70,175	32,191
2040	371,505	44,224	37,701	33,968	29,206	13,840	77,014	43,046
2050	392,031	44,337	42,920	34,628	26,588	18,893	80,109	45,481
				Percent of All Ages				
2000		13.1%	8.6%	6.7%	4.5%	1.6%	12.8%	6.4%
2010		14.7%	11.5%	7.0%	4.4%	2.0%	13.3%	7.3%
2020		11.9%	13.0%	9.5%	4.7%	2.1%	16.4%	8.5%
2030		11.1%	10.7%	10.9%	6.7%	2.5%	20.1%	12.2%
2040		11.9%	10.1%	9.1%	7.9%	3.7%	20.7%	16.3%
2050		11.3%	10.9%	8.8%	6.8%	4.8%	20.4%	17.3%

U..S. Bureau of the Census
Current Population Reports, P25-1104
(000's)

This growth in the population of older adults represents a profound demographic shift that will impact all aspects of our society. It represents as well a unique challenge to the community of transportation officials. The actions we can take now to get the system ready will have an important effect on the lives of future older Americans.

1.1.2 Older Adults as an Economic Force

Social Security and Medicare transfer payments alone average almost $12,200 per person for those over 65. This is expected to increase to $23,600 (1993 dollars) by 2030. In terms of assets, as a group, adult householders 65 and older have a median net worth of $88,192, as compared to householders under 35 whose net worth is $36,623. Even excluding home equity, those over 65 average a net worth more than eight times those under 35.

In 1992, only 12.9 percent of older adults lived at or below the poverty level ($6,729 for a single-person household and $8,437 for an elderly couple) as compared to 14.7 percent of the population under age 65.[8] However, older adults in the United States are diverse in their financial status. For this segment of the population, the U.S. Census reports significant differences in income related to characteristics such as age, sex, race, ethnicity, marital status, living arrangements, educational attainment, former occupational status, and work history. [9] At the lower end of the income spectrum, 26 percent of older adults relied on Social Security benefits for more than 90 percent of their income. And Social Security was the sole income source for 14 percent of the older adults.[10]

1.1.3 Retirement Patterns

Some transportation problems for older adults are directly associated with their patterns of retirement:

> Location - Data show that more than 90 percent of Americans retire in place (in the same community and often at the same address they lived at before retirement). That means that many older adults retire in the suburbs, exurbs, and rural areas where transportation is strongly dependent on the automobile.
>
> Living Status - Thirty percent of the older adult population live in single-person homes. Forty percent of those are women living alone.

1.1.4 Maturing Baby Boomers

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8. U. S. Census, 1996, p. 4-16.

9. U. S. Census, 1996, p. 4-8.

10. U. S. Census, 1996, p. 4-14.

The first of the Baby Boomers, those born in 1946, reached age 50 in 1996. They will reach age 65 in 2011 and start to enter the older adult category. They may be more accustomed to automobile mobility than are current older adults. Unlike current older adults, most women will have a drivers license as future generations approach universal licensing.

1.2. OLDER OPERATORS BY MODE

Over one-half of people eligible now take Social Security at age 62. However, gradual increases in the eligible age for full Social Security will start in 2003. People born after 1960 will not be eligible for full Social Security benefits until age 67. Thus, we can expect that there will be more older adults in the commercial workforces for air, trucking, rail, marine, and other modes.

The present population of older operators is shown in Table 2 (see next page). Along with the maturing of the modal workforces, in some industries there are increasing economic pressures to extend work life and to postpone retirement. Today, there are incentives for retaining older truck operators as decreased entry and quick turnover of younger drivers makes the existing driver pool smaller. The growing need for operators in some commercial transportation industries is seen in Table 3, which shows the projected percentage increase in workers from 1994 to 2005.

Table 3. Forecast Increase in Commercial Operators by Mode
Source: Bureau of the Census Current Population Survey, 1995

Mode	Operators	1994 to 2005 Increase in Need
Highway:	truck drivers	11%
	bus drivers (except school)	17%
	school bus drivers	16%
Air:	pilots and flight engineers	8%
Maritime:	ship's officers	6%

Table 2. Age of Selected Commercial Transportation Occupations

Occupation	Total aged 16+	Aged 55 +	Aged 65+	% 55 +	% 65+
Truck drivers	2,861	347	66	12.1%	2.3%
Bus drivers	526	131	43	24.9%	8.2%
Taxicab drivers & chauffeurs	213	54	23	25.4%	10.8%
Railroad conductors & yardmasters	33	6	0	18.2%	0.0%
Locomotive operating occupations	51	6	0	11.8%	0.0%
RR brake, signal, and switch	17	5	0	29.4%	0.0%
Ship captain & mates*	33	5	1	15.2%	3.0%
Sailors & deck hands	26	2	0	7.7%	0.0%
Marine engineers	3	0	0	0.0%	0.0%
Bridge, lock, & lighthouse tenders	4	1	1	25.0%	25.0%

Source 1995 Bureau of the Census' Current Population Survey

Numbers in "1000s"

* excluding fishing boats

Age of Individuals Holding Commercial Drivers Licences	Total aged 15+	Aged 56 +	Aged 66 +	% 56+	% 66+
	7,747,519	676,729	301,173	8.7%	3.9%

Source American Motor Vehicle Association 1995

Age of Locomotive Engineers	Total all ages	Aged 55 +	Aged 65 +	% 55+	% 65+
	20,856	3,153	99	15.1%	0.5%

Source National Railway Labor Conference 12/94

Age Distribution of Airmen of Medically Certified 1st, 2nd, 3rd Class Airmen

	Total all ages	Aged 55 +	Aged 65 +	% 55+	% 65+
Air Transport Pilots	143,398	12,608	714	8.8%	0.5%
Commercial Pilots	162,284	28,402	8591	17.5%	5.3%
General Aviation	308,388	64,486	23678	20.9%	7.7%

Source Civil Aeromedical Institute 12/94

1.3 OLDER ADULTS' INTERFACE WITH THE TRANSPORTATION SYSTEM

Americans prize mobility and older adults in their golden years are no exception. A substantial amount of work is underway within DOT to support the safe mobility needs of older adults. (NHTSA) has had an older driver program since 1988. FHWA embarked on a major program in 1989 for improving highway travel for an aging population.[11] Federal Transit Administration (FTA) grant programs for older adults and persons with disabilities, for rural transportation, and for paratransit, all provide benefits to older adults. Additional details on these programs are found below and in Appendix A.

Nevertheless, there are still many elements in the current transportation system that present major barriers to some older adults. These elements include aspects of highway design, like freeway entrances, intersection configuration, long cross walk distances relative to older pedestrian walking speeds, placement of signs relative to decision points, and the size of letters on signs.

Many older adults have difficulty in using some vehicles. Kneeling and low floor buses are helpful, but most vans are very difficult for the older adults to get on and off. Cramped airplane, bus, or train lavatories, narrow aisles, and overhead racks or bins may be difficult to use for older travelers. Few employees have sensitivity training for dealing with older adults or training on how to help evacuate older adults in an emergency.

Bus, rail, and aviation terminals present special problems for many older adults. Problems include signs that are difficult to read or interpret, long walks from one area to another especially in large airports, lack of places to sit or rest, and difficulty in boarding commuter planes.

Older adults are less resistant to trauma caused by transportation crashes. Osteoporosis is prevalent, particularly among older women. Safety belts that protect younger persons may injure older adults. Similar problems related to fragility may exist with airbags. Slipping and falling accidents in terminals, transit stations and on urban buses represent a significant risk of injury.

Many older adults continue to hold or would like to hold post-retirement jobs in order to supplement their incomes, and add to their community involvement. Transportation can become a barrier to the taking on of such jobs, either because of the lack of non-driver alternatives, or because of its relatively high cost compared to the low pay such jobs usually entail.

The U.S. life style is based on full mobility, and for most, this means we have a primary dependence on operating or riding in private automobiles. As a result, we need to make major adjustments when we can no longer drive. Regulation and custom have defined the point at which young people are sufficiently mature to operate the various transportation modes. This is

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11. A number of elements for these programs were proposed in 1988 by a Committee of the Transportation Research Board; see "Transportation in an Aging Society, Special Report 218," National Research Council, Washington, DC, 1988.

accomplished by means of an age threshold plus licensing and certification procedures. As transportation technologies have developed, the definitions of maturity and skill required for beginning operation have been refined. However, as the number of operators in the older segment of the population expands, questions have arisen whether these older workers retain the requisite abilities to operate the transportation systems safely.

Restrictions in the ability to operate personal vehicles due to age-related reductions in capacities can isolate individuals from full participation in society. Technological change may represent both a significant hope and challenge for older adults. Technology brings with it a promise of benefits in the ability to overcome limitations of older operators. However, the technology may come at the price of increased cognitive workload. In some areas, aging operators, because of seniority, are likely to be the most challenged by this new workload in some industries. To complete the circle, technology itself can be used to mediate the cognitive workload. The goal must be to develop human-friendly technology, and particularly elder-friendly technology.

1.4 THE AGING PROCESS

Generally, aging results in the decrease of physical and mental capabilities as the result of various forms of “normal” deterioration. With aging there is also an increased frequency and severity of disease. While some diseases and deteriorations may present themselves suddenly, generally there is a slow build-up of deficits.

This aging process varies widely from person to person. In general, older adults do not perform as well as younger adults on almost all available measures of physiological functioning. However, in many cases, these deficiencies are small and the range of measured responses often overlap, with some older adults functioning better than their younger counterparts. Therefore, these average measures for any chronological age can not predict individual performance. At best, only generalities can be made regarding the physiology and functioning of older adults in comparison to younger adults.

Differences among individuals widen as age increases, which makes analysis and policy making on aging difficult. Even if aging changes were precisely identified, the impact on transportation would not always be clear. Humans compensate for deficits by finding alternative ways to perform desired activities.

The following principles define aging:

- Aging is universal and inevitable but not necessarily predictable;

- Aging-related changes are characteristically detrimental in nature, cumulative and irreversible over time, but often lack sharply defined points of transition;

- As the human animal ages, homeostasis becomes more difficult to maintain as resistance to environmental stress declines;

- Changes begin at different chronological ages, progress at varying rates, and do not affect each body system in the same way or follow an identical course; and

- There are wide individual and socio-cultural variations to the aging process.

1.4.1 Aging vs. Disease

The normal process of aging is associated with increased incidence and severity of diseases. For some, several diseases may present at once. Although disease can often be treated and its effects halted or even reversed, the body of the older person rarely returns to full pre-disease efficiency.

The universal consequence of the aging process on the human body is a decrease in the efficiency and ability of the body to maintain functional levels within normal limits while under stress, and the slowed rate of return to normal levels once systems are stressed. Conduction velocity of nerves, cardiac output, renal function and respiratory function are all less capable of withstanding stress in older adults.

Aging, therefore, becomes the succession of events that accumulate and increase the probability and onset of functional failure. As the prevalence of chronic disease increases with age, it becomes more difficult to differentiate between functional loss due to the effects of disease versus that concomitant with the normal aging process.

1.4.2 The Heterogeneity of the Aging Process

The aging process involves complex interactions of genetic and environmental influences. There is a lack of uniformity of age-related changes between individuals and within the same individual. The onset, rate and degree of changes vary depending on the organ, system, or function in question.

It is important to consider the compensatory responses that can counteract losses due to aging, and the potential for rehabilitation to make up for functional losses. However, the heterogeneity among individuals increases with age, both in terms of decrements themselves and the compensatory ability to offset decrements. While a single impairment might be compensated for with relative ease, multiple impairments are more difficult to overcome. This extreme heterogeneity of functional status strongly supports the view that older adults must be evaluated on an individual basis, especially as health and fitness status, and social, economic and environmental conditions continue to impact how Americans age.

1.4.3 The Effect of Aging on Functioning

Sensory functions such as vision and hearing diminish with age. Cognitive functioning, including attention, memory, and learning ability, is also negatively impacted by the aging process. While crystallized intelligence (the ability to learn from experiences) and verbal skills are usually maintained into old age, fluid intelligence (the ability to think and reason abstractly) and nonverbal skills show measurable losses.

Although psychomotor functions such as reaction time slow with age, older operators often compensate by substituting experience, accuracy and consistency for speed of response. Physical strength often decreases dramatically after age 60 while work capacity decreases significantly after age 70, although again there are wide individual differences. The normal aging process also has a decremental affect on body conformation and composition, tissue and organ systems and cardiovascular and respiratory systems. For a detailed discussion of physiological changes due to the normal process of aging refer to Appendix B of this report.

Since the prevalence of many medical conditions increases with age, those that may impair the cognitive, sensory or psychomotor skills necessary to operate a vehicle safely need to be identified. Impairing conditions are of concern because they affect functional capacities. Older individuals tend to have more chronic musculo-skeletal disorders and, as a whole, are less flexible than younger drivers. This affects the ability of older drivers to turn their heads when turning and merging. There are also restrictions in "useful field of view" or UFOV, which involves the processing of visual information and is most critical in complex or novel situations. Dementia, as characterized by diminished cognitive abilities in judgment and memory, is of particular concern. Other medical conditions may be of concern either because they may cause an individual to lose consciousness while operating a vehicle or prevent adequate bodily control of a vehicle. Those medical conditions and disease processes that may have an adverse effect on an individual's ability to operate a vehicle safely are discussed in detail in Appendix B.

1.4.4 Fragility

Older drivers tend to be over represented in fatal and serious injury crashes where they, themselves, are the victims. One explanation is their increased fragility. The results of the normal aging process and the presence of certain disease processes combine both to decrease the older individual's ability to withstand trauma, and to increase the likelihood of post-traumatic complications that can result in death, extension of disability or a prolonged recuperative period. Approximately one-third of the health care costs expended on injury are spent on the elderly although they represent only 12 percent of the U.S. population. Higher post-traumatic hospital and nursing home costs for older adults are due not to a higher level of initial severity but to the increase in subsequent complications and increased recovery times. One study found that 72 percent of older victims who survived serious trauma and were discharged from the hospital remained in a nursing home one year later (DeMaria, 1993)[13]. Optimistically, other studies have shown that the majority of older trauma victims eventually return to the quality of life they had

prior to the injury (DeMaria, 1993). The leading predictor for mortality following traumatic injury is advanced age. The same traumatic injury that kills 10 percent of the 65- to 79-age cohort will result in the death of nearly 50 percent of the cohort aged 80 and above. The primary reason for the higher mortality rate has been attributed to the increase in post-traumatic cardiac, pulmonary and septic complications suffered by trauma victims over age 80.[12]

1.5 MEDICAL CONSIDERATIONS VS. RELATIVE RISK

1.5.1 Medical Conditions

Further study is needed to determine the relative risk of medical conditions for increased likelihood of impaired vehicle operation. Research in this area is currently under way in the Department of Transportation. This type of analysis should help identify the relative risk of the presence of medical conditions as well as the severity level or stage of those conditions. Previous studies have been hampered by methodological problems that have made their results suspect or inconclusive.

The usefulness of a relative risk scale is two-fold. A relative risk scale could serve as a guideline to assist the medical and allied health professions to identify those patients who need further evaluation, monitoring and rehabilitation to continue to drive safely, and to identify those patients who should be counseled to limit or desist from driving altogether. The relative risk scale could also serve as a tool for establishing the appropriate regulatory determination of licensure eligibility. Currently states vary widely in terms of private automobile re-licensure requirements for the elderly. Table 4 lists requirements for license renewal for the U.S. and Canada. Table 5 lists similar information for other countries.

For a relative risk scale to be useful in application to older operators, the deficits of normal aging and the co-occurrence of disease conditions would have to be included. For example, the relative risk of a younger diabetic may be drastically lower than an older diabetic who also suffers from heart disease and arthritis. Severity or stage of condition is also crucial in determining fitness to drive. Some studies have concluded that mild cognitive impairment does not increase the risk of operating a vehicle safely while moderate to severe cognitive impairment precludes the safe operation of a vehicle altogether. Additionally, while an individual's ability to cope with one limitation may be sufficient for safe vehicle operation, additional deficits interfere with that ability to cope.

Once identification and assessment tools such as a relative risk scale are developed, the determination of what to do with those people who are deemed "high risk" remains. Acceptable versus unacceptable risk levels have to be determined before a relative risk scale can be applied in establishing consistent regulatory guidelines. The relative risk of medical conditions and

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12. DeMaria, Eric J. "Evaluation and Treatment of the Elderly Trauma Victim." Clinics in Geriatric Medicine. 9(2):461-471 (May, 1993).

Table 4. Jurisdictions Requiring In-person Renewal and Conditions
U.S. States as of 1994

Jurisdiction	Interval/Conditions	Vision Test
Alabama	4 years	no
Alaska	5 years	yes
Arizona	4 years	no
Arkansas	4 years	yes
California	4 years (poor drivers), 12 years (good drivers), at age 70+ in-person renewal only	yes
Colorado	2 years if age 16, 3 years if age 18, 5 years after age 21, 4 years for CDL	no
Connecticut	4 years, 6 months if public service operator & age 70	no
Delaware	5 years	yes
District of Columbia	4 years, at age 70, physician certificate required plus reaction test, at age 75, additional knowledge/road tests (optional)	yes
Florida	4 years, 6 years if no convictions within 3 years	yes
Georgia	4 years	no
Hawaii	2 years if ages 15-24 including knowledge and signs test, 2 years at age 65+ includes knowledge and signs test every 4 years, 4 years ages 25-64	yes
Idaho	4 years	yes
Illinois	4 years, 2 years at age 81-86, 1 year at age 87+; written and road test at 69+	no
Indiana	4 years, 3 years at age 75	yes
Iowa	2 years if under 18 or 70+, 2 or 4 years between ages 18-69	yes
Kansas	4 years includes open book written test	yes
Kentucky	4 years	no
Louisiana	4 years	yes
Maine	4 years, at age 40+ every 12 years, at age 65+ every 4 years	no
Maryland	5 years	yes
Massachusetts	4 Years	yes
Michigan	4 years (good drivers) includes knowledge and sign tests, 2 years (drivers with moving violation in last 4 years)	yes

Table 4. Jurisdictions Requiring In-person Renewal and Conditions U.S. States as of 1994 (continued)

Jurisdiction	Interval/Conditions	Mandatory Vision Test
Minnesota	4 years	yes
Mississippi	4 years	no
Missouri	3 years	yes
Montana	4 years	yes
Nebraska	4 years	yes
Nevada	4 years	yes
New Hampshire	4 years, at age 75+, knowledge and road test	yes
New Jersey	4 years	no
New Mexico	4 years, 1 year at age 75+	yes
New York	4 years	yes
North Carolina	5 years; knowledge testing	yes
North Dakota	4 years	yes
Ohio	4 years	yes
Oklahoma	4 years	no
Pennsylvania	4 years	no
Oregon	8 years, 4 year cycle with one mail renewal	yes at age 50
Rhode Island	5 years, 2 years at age 68+	yes
South Carolina	4 years	yes
South Dakota	5 years	yes
Tennessee	5 years	no
Texas	4 years	yes
Utah	10 years, mail renewal acceptable every other cycle (5 years) if no more than 4 convictions in preceding 5 years, 5 years at age 64+	yes
Vermont	2 and 4 years	no
Virginia	5 years	yes
Washington	4 years	yes
West Virginia	4 years	no
Wisconsin	4 years	yes
Wyoming	4 years	yes

Table 4. Jurisdictions Requiring In-person Renewal and Conditions
Canadian Provinces as of 1994 (continued)

Jurisdiction	Interval/Conditions	Mandatory Vision Test
Alberta	5 years; medical at age 75+	no
British Columbia	2 and 5 years	no
Manitoba	4 years for photo only	no
New Brunswick	4 years	no
Northwest Territories	5 years	no
Nova Scotia	3 years	no
Ontario	3 years	yes
Prince Edward Island	3 years	yes
Quebec	2 years	no
Saskatchewan	5 years	no
Yukon	3 years	no

Table 5. International Renewal Requirements

Country	Renewal Procedures	Renewal Interval	Renewal Requirements
Belgium	No	No renewal required?	No
Denmark	Yes	At age 70, licenses issued for 4 years At age 71, licenses issued for 3 years At ages 72-79, licenses issued for 2 years At ages 80+, licenses issued for 1 year Due to illness, a shorter term can be stipulated	Doctor's certificate required
England	Yes	At age 70, mandatory renewal	After age 70, a medical certificate required After age 70, vision test required
Finland	Yes	At age 45, renewal required every 5 years License issued for 5 years or less At age 70 license expires Renewal period depends on the physician	After age 45, medical review every five years Covers general health status and vision Renewal requires medical exam and verification of ability by two people
France	No	No renewal required	No
Germany	No	Renewal not determined by age	No
Ireland	Yes	Annual renewal regardless of age	At 70, a certificate of medical fitness is required
Italy	Yes	10 year renewal up to age 50, 5 year renewal after age 50 and 3 year renewal at age 70	Medical test required with renewal, may be more frequent after age 65 At age 60, not allowed to operate buses, coaches Waiver up to age 65 with medical certificate
Luxembourg	Yes	At age 70, can only renew for 5 years	At age 70, not allowed to have commercial license
Netherlands	Yes	At age 70, medical review required every five years	Depending on physical conditions, medical review may be more frequent, vision test required
New Zealand	Yes	No renewal required until age 71 At age 71, license renewed for 5 years At age 76, resettled every two years	At age 71, medical review and eyesight test required At age 76, road test required in addition
Portugal	Yes	At age 70, license renewed every 2 years	At age 70, a medical exam is required every 2 years
Sweden	No	No renewal required	No
Slovenia	Yes	At age 65, the validity of licenses is a 3 year maximum	At age 65, a medical exam is required at least every 3 years

disease processes can be utilized effectively by the medical and allied health professions in the interim. They can provide guidelines for identification and counseling. It is believed that a mild risk deemed acceptable for a driver of a private automobile on limited local trips could be wholly unacceptable for a commercial operator responsible for the lives and safety of many others.

1.5.2 The Role of the Medical Community

The medical community and particularly physicians could play a heightened role in the identification of older drivers at high risk for motor vehicle crashes. Physicians have the clinical training and diagnostic skills to identify and advise patients who may be at-risk. They also have frequent exposure to the older population at-risk. The social workers' role usually is to determine the need for continued driving once limitations have been identified and to locate alternatives for the impaired individual. The occupational therapist plays an invaluable role in determining whether an individual, whose capacity for driving has been compromised, can through training and rehabilitation return to driving. Assessment and training programs run by occupational therapists expert in impaired drivers vary widely, and physicians are aware of them mostly by word-of-mouth. Existing medical and non-medical referral systems fall short in accommodating the needs of the impaired older driver.

1.5.2.1 Concerns Inherent in the Evaluation Process - A prime responsibility of the physician treating an elderly, community-dwelling patient is to enable that patient to maintain his or her independence. Access to transportation is crucial to meeting the social, medical, economic and other basic needs of the elderly. More often than not, transportation is provided by the private automobile. Without access to their own car, many elderly would become isolated and unable to meet their most basic needs.

The medical community also has ethical and legal obligations for maintaining public safety. If their elderly patient is at high risk for a motor vehicle crash, then that person poses a threat to him/herself and to the public. The conflicting obligations present an ethical dilemma to physicians and allied health professionals.

- When does a patient's age-related or disease-related deficits constitute a need to recommend that their patient cease driving?

- When is the degree of risk sufficiently high to warrant the tradeoff of independence that an automobile provides?

- What risks does the physician face in terms of liability for not intervening or reporting a patient who continues to drive against medical advice?

- To what extent might a patient seriously in need of medical help avoid consulting a physician for fear of losing driving privileges?

Retchin and Anapolle (1993)[13] recommend that physicians use a driving history assessment as part of their social evaluation of geriatric patients and be prepared to counsel patients regarding their driving ability. Physicians should also be well versed regarding evaluation requirements in their state, the availability of assessment and training programs and statutes regarding their obligation to report patients who may be a threat to themselves or public safety. Underwood (1992) [14] provides assessment recommendations for physicians to utilize with older patients who drive, as well as clinical recommendations for the prevention of motor vehicle crashes.

Physicians have a fiduciary responsibility toward their patients that dictates the confidentiality of the physician-patient relationship. This relationship allows for the patient to disclose information that will assist in accurate diagnosis and treatment without fearing repercussions. Physicians also have a legal responsibility toward protecting the public interest or the private interest of their patient which supersedes confidentiality. This duty to warn regarding public hazards is the basis for statutes that require physicians to report patients who are a threat to third-parties, particularly in cases of psychiatric illness and communicable disease. In terms of driving, physicians have been held liable for failure to warn patients about the danger of driving with certain illnesses or while taking certain medications. Physicians can also be held negligent for failure to properly diagnose an impaired patient.

Reporting impaired patients to the authorities is required in cases of a "foreseeable" threat. Therefore, appropriate evaluation, diagnosis and documentation of functioning deficits, or lack thereof, are critical in protecting the physician from the legal ramifications of caring for the elderly driver. Reporting requirements vary from state to state. Some states allow anonymous reporting while others require the reporting of specific diagnoses.

Physicians and allied health professionals will face this issue with greater frequency as their patient population base ages. Driving history and other assessment tools are available to help identify those patients who may present a threat to themselves or others. The relative risk scale discussed above that provides guidelines regarding the risk of driving with certain medical conditions would assist the medical community in advising older patients and their families about driving capability and privileges. Physicians have the clinical training and diagnostic skills to identify and advise patients who may be at-risk. They also have frequent exposure to the older population at-risk. Koepsell, et al (1994)[15] reported that nearly 97 percent of the older drivers they studied who were injured in motor vehicle crashes had visited a physician at least once in

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13. Retchin, Sheldon M., and Jackie Anapolle. "An Overview of the Older Driver," Clinics in Geriatric Medicine. 9(2), 279-295 (May, 1993).

14. Underwood, Michael. "The Older Driver: Clinical Assessment and Injury Prevention," Archives of Internal Medicine. 152:735-740 (April, 1992).

15. Koepsell, Thomas D., Wolf, Marsh E., McCloskey, Lon, Buchner, David M., Louie, Douglas, Wagner, Edward H., and Robert S. Thompson. "Medical Conditions and Motor Vehicle Collision Injuries in Older Adults," Journal of the American Geriatrics Society. 42:695-700 (1994).

the year prior to their injury. Inclusion of driving history in the social evaluation of patients and functional assessment tools in routine clinical care could result in preventive intervention to almost all older drivers at-risk.

The physician's role in the evaluation and treatment of the elderly operator should be regarded as a pivotal challenge in the complicated management of the health of the elderly population.

1.5.2.2 The Role of the Occupational Therapist in Screening and Evaluation of the Older Driver - Occupational therapists (OTs) are trained to assess and treat those who are impaired by birth defect, injury, disease or the aging process. They help people with disabilities adapt so that the disabled are better able to carry out life's tasks. Occupational therapy can and does play an active role in the evaluation of elderly individuals' driving abilities. Through the application of evaluation methods, OTs strive to first determine an individual's capacity for driving and then to identify those factors which through training and rehabilitation could improve an individual's driving ability.

The need for a formal driving assessment may be indicated by an individuals perceived decrement in ability or at the suggestion or requirement of family members, physicians or regulatory agencies. A new and permanent change in condition such as stroke, brain injury or hip replacement should also indicate the need for a formal assessment before the individual resumes driving (Cifu, 1993)[16].

Evaluation methods and training programs vary, as does the availability of OTs trained for driving assessment and rehabilitation. The evaluation usually consists of a pre-driving assessment including psychometric tests and an on-the road (or off-the-road course) driving tests. Some programs utilize simulators along with, or in place of a road test, but many OTs question the ability of driving simulators to capture the true driving experience especially with the elderly (Hunt, 1993)[17]. The cost and availability of simulators can also be prohibitive.

The pre-driving assessment usually consists of an interview, review of medical and driving history, license eligibility and evaluations of sensory, cognitive and motor ability. The purpose of the interview is to determine why the older driver requires evaluation and whether the individual recognizes their limitations. In order to implement a compensatory plan to improve driving ability the older driver must first acknowledge the limitations that exist. The medical and driving history and license eligibility is reviewed to determine if there are specific limitations which indicate the need for special modifications or adaptive equipment or preclude driving altogether. The motor, sensory and cognitive evaluations determine not only the capabilities and limitations

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16. Cifu, David X., "Rehabilitation of the Elderly Crash Victim," Clinics in Geriatric Medicine. 9(2):473-483 (May, 1993).

17. Hunt, Linda A, "Evaluation and Retraining Programs for Older Drivers," Clinics in Geriatric Medicine. 9(2):439-447 (May, 1993).

of an older driver but also the ability and likelihood for rehabilitation. These off-the-road tests are performed prior to a road test to determine if the older individual is safe to drive at all and to determine if training and compensatory adjustments need to be made prior to the road test. If, for instance, range of motion or vision is so impaired as to render the individual unsafe to drive, the evaluation turns to identifying if an exercise program or medical intervention would be effective in ameliorating the deficit. If the pre-driving tests determine that an individual lacks the judgment to drive safely, cognitive testing should be undertaken to determine the extent and cause of cognitive impairment and the possibility for rehabilitation. Outcomes would be used to provide recommendations regarding the administration of a road test.

The road test may be performed by the OT alone, by a driving instructor alone, or by both. The OT would advise the instructor of any problems and a test or course would be designed to test those abilities in question as well as other crucial driving tasks. The individual is usually tested in their own car. The course may be one familiar to the older individual or a course chosen to test specific tasks and abilities. The final determination of ability to drive is made by the OT and the driving instructor together. The OT then designs a training program to address those factors which the assessment has identified as rehabilitative deficits.

These assessment and procedure tools can identify those elderly drivers who could benefit from training and a tailor-made training program can be designed to meet the individuals particular needs. The final assessment may also lead to recommendations of voluntary restriction of driving, such as daytime only or limiting to a familiar location. A basic driver's assessment and training program costs between $350 and $1,000 (Cifu, 1993)[17]. More extensive rehabilitation and adaptive devices add to the total costs.

1.5.3 In Summary

Aging is associated with an increased incidence and severity of diseases. They collectively increase the probability and onset of functional failure and disease. The prevalence of many medical conditions increases with age. Those conditions that impair the cognitive, sensory, or psychomotor skills required to operate a vehicle or other transportation system safely should be identified and evaluated for the risks represented. Among the conditions that increase with age and impact mental and physical functions are: dementias, cardiovascular conditions, cerebrovascular conditions, diabetes mellitus, epilepsy, ocular system disease, chronic obstructive pulmonary disease, arthritis, medications, and polypharmacy.

The level of mental and physical performance appears to remain higher and to last longer for today's elderly compared with earlier generations. Many of today's older adults have benefited from increased education, and adoption of healthier life styles including: increased exercise, abstinence from tobacco products, moderation in the use of alcohol, and dietary changes. These changes appear to have delayed the negative consequences of aging.

Improved medical procedures and diagnostic techniques also play an important role in supporting the extension of full functionality into older age. Examples of these improvements include better cardiovascular procedures and medicines, better oncology treatments, advanced technologies and other interventions to enhance sensory functions, and improved techniques that directly affect mobility such as hip replacements. However, the extended period of well-being resulting from improved life style and medical technology is not without limits and can sometimes be followed by a rapid decline.

The continued anticipated growth in the number and proportion of older U.S. citizens who are vehicle operators during the next several decades will increase the significance of the impact of medical, ethical, and health policy issues on safe mobility. This impact will be a function of the number of individuals capable and willing to operate vehicles, the availability of alternative forms of transportation, and how vital services are made available.

Medical services become increasingly important to an aging population. Assuming that the same economic forces continue to affect the U.S. health care system, there will be no decline in the growth of outpatient procedures. With the continued development of sophisticated medical technologies, we can also anticipate increases in the number and types of treatments that require frequent scheduled administration. This will make the continuation of mobility for older adults even more important. As an example, reliance on frequently scheduled blood dialyses for individuals with kidney disease has made mobility a survival issue. Such economic and technological factors will make the need for continued mobility critical for our elderly population.

Although data aggregated across the population as a whole show a smooth decline in mental conditions and physical capabilities, individuals often experience episodic incidents of mental and physical decline. People age differently and differences among individuals' capabilities increase with age. If an age were to be selected for the average onset of some functional impairment among the population, 75 years old might be such a threshold. However, the use of chronological age as a substitute for measures of functional capacity raises a host of problems.

At this time, it is unclear what the specific relationships are among different types of medical conditions and the safe operation of vehicles and other transportation systems. Objectively assessing these relationships is a very complex process because many people with such conditions develop strategies to compensate for individual functional deteriorations. They try to avoid those conditions where the deterioration is most problematic. Many older drivers curtail their night driving in response to visual losses.

Until we have widely accepted objective tests to measure functions critical to safe and effective operations, age will remain the only universal, objective, and quantitative index available for use in law and regulation. Notwithstanding the absence of objective criteria and tests, judgment of ability or competence made solely on the basis of age is often seen as a form of discrimination. One long term goal should be establishment of mental and physical criteria that are independent

of age. Ideally we should be able to relate these functional criteria to an individual's ability to operate his or her vehicle safely and effectively.

2. SAFETY IN TRANSPORTATION

2.1 ADAPTATION AND SELF REGULATION

As noted in the previous section, there is a slow accretion of deficits at rates that vary widely among people. This extensive variation in performance capabilities and differing abilities to adapt to the limitations these deficits present, indicates why we must eventually move to more age-neutral, performance-based screening and evaluation systems.

2.1.1 Private Motorist

Generally most people self-regulate when operating their private vehicles. For older motorists, maturity and experience typically help compensate for declining skills. In general, older adults reduce their driving as their skills decrease. As a result, contrary to widely held stereotypes, the crash rate per older licensed driver is low, as illustrated in Figure 2. For some, the sudden onset of a serious disabling condition makes driving impossible. Most, however, withdraw from driving gradually and responsibly. They make strategic decisions to drive less frequently, over shorter distances, avoid driving at night, in rush hours, in bad weather, in unfamiliar places, or on crowded or high speed highways. A small number of people whose judgment has deteriorated may not recognize their incapacities and not give up driving. The irresponsible actions and widely publicized crashes of this small subset may give an incorrect impression of the driving behavior of the entire older adult population.

The effects of such mental pathology on driving safety can be troublesome. Senile dementia, particularly Alzheimer's disease, is worth special consideration because those so afflicted may not self regulate as much as those unafflicted. Or if they do self regulate, they may not do so effectively. Operators may lack the awareness that their skills are eroding and may not seek or accept the advice of others. They actively deny there are any age related declines. Such individuals (men, more so than women) usually will not seek or accept the advice of others. Obviously, intervention is needed in such cases.

The perception of an older driver safety problem may also come about when the crash rate per mile driven is examined. The fatality rate per 100 million vehicle miles traveled stays reasonably level for drivers up to age 75, and then increases, climbing steeply for persons over 80 (see Figure 3). The much higher fatality rate for those over 80 is partly attributable to their greater fragility (see Figure 4), and the vastly reduced recuperative capacity of older adults, compared to younger persons.

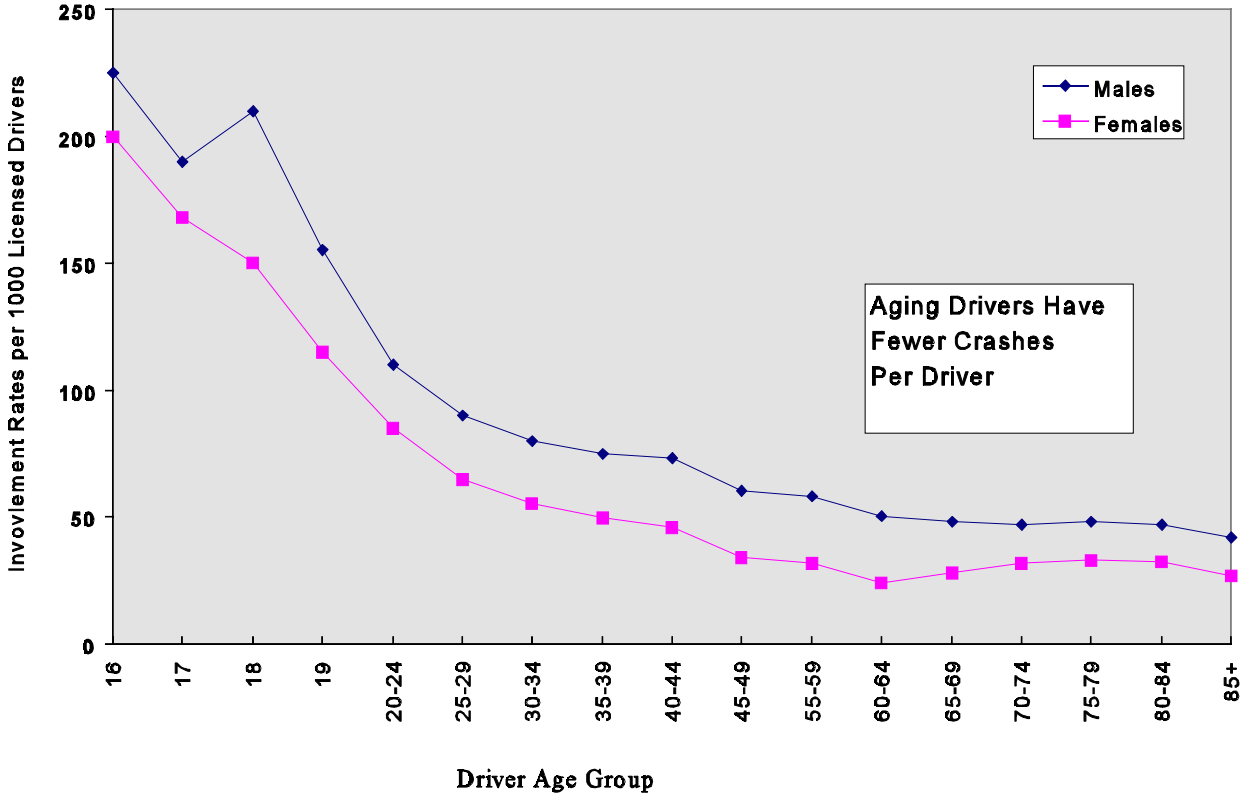

Figure 2. Crash Involvement Rate Per 1000 Licenced Drivers

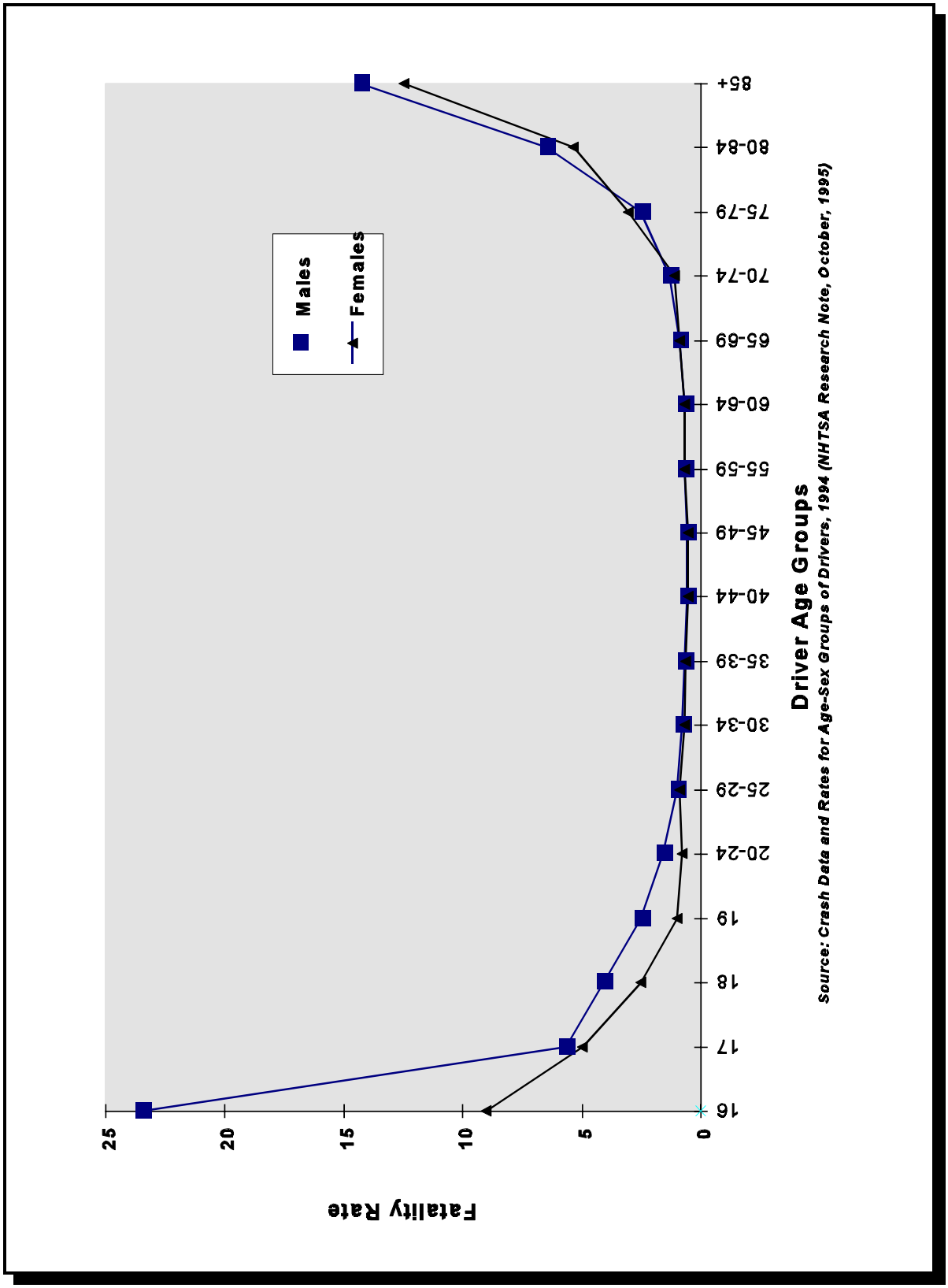

Figure 3. Driver Fatality Rate 1994 (per 100 Million VMT)

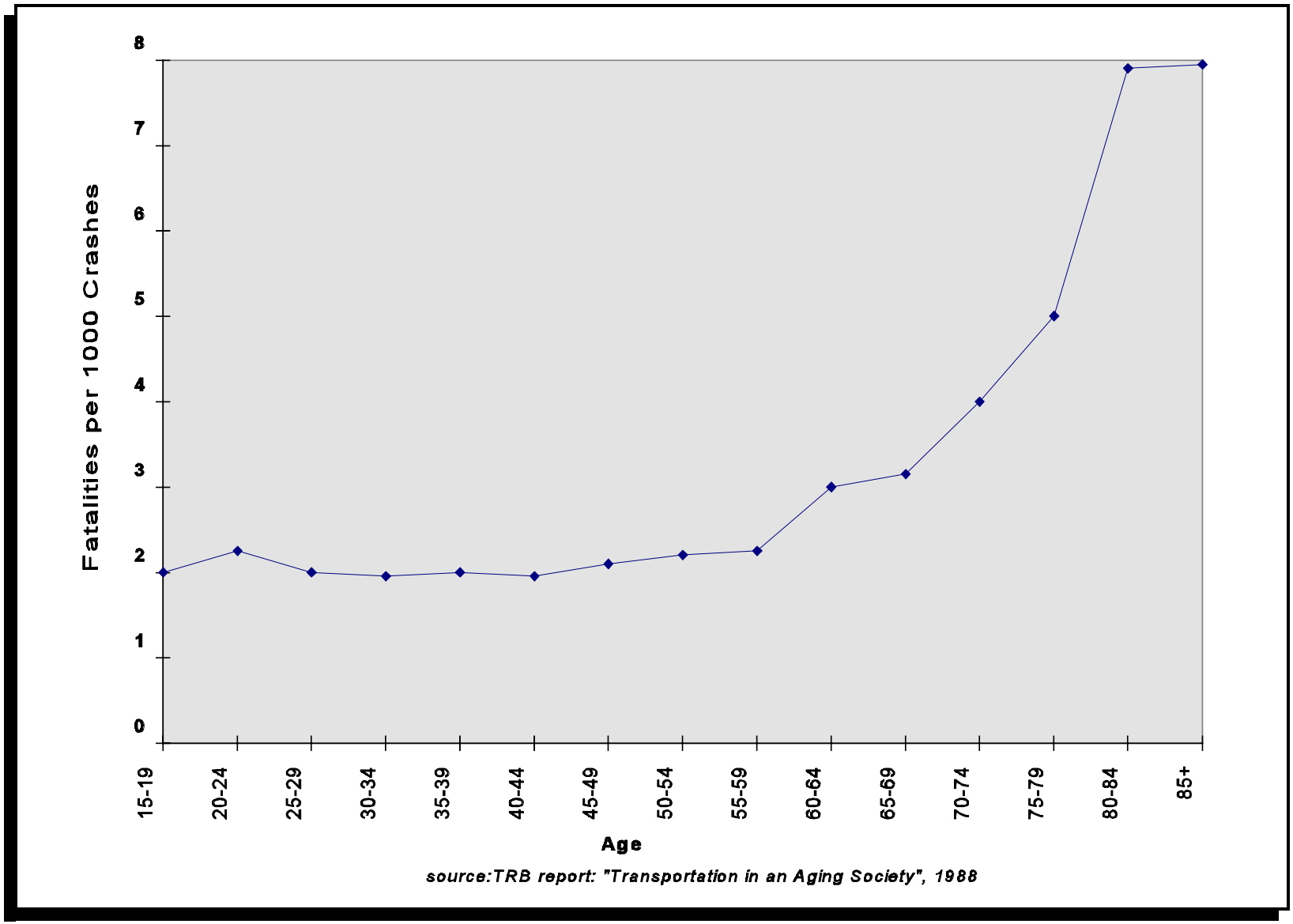

Figure 4. Age/Fragility Relationship Fatalities per 1000 Crashes

By 2020 there will be an additional 20 million more older adults in the population and presumably on the road in at least the same proportion as they are today. For the group aged 75 and above, a linear projection of today's population-based fatality rates indicates that fatalities could increase by 45 percent or more. In addition, current trends toward a higher proportion of licensed drivers in the older population, and a more disbursed retired population (implying higher VMT per driver) could increase the number of fatalities for those aged 75 and above even higher, unless the safety community can lower their crash rate or increase their crash protection.

By age 85, women outnumber men by 5 to 2 in the population. By age 85, 80 percent of formerly licensed older women have stopped driving. Men are less likely to curtail driving with 60 percent above 85 indicating they drive.[18] One reason that fewer males than females cease driving is that males are more likely to overestimate their driving capabilities and skills. This tendency to overestimate driving skills may not be the only reason men are less likely to cease driving earlier. Driving continuation may also result from perceived responsibilities as transportation providers.

There is one study that indicates that older motorists are over-represented in crashes involving heavy trucks.[19] This analysis provides little explanation as to why there is a higher proportion of crashes involving trucks and cars being driven by older adults than cars being driven by the population at large, or why these crashes result in a higher number of fatalities. The fragility of older adults is one obvious factor regarding the latter. The extent to which differences in speed between trucks and cars driven by older adults along the highway could be another factor, and this warrants further investigation.

2.1.2 Commercial Operators

Maturity and experience can also compensate for loss of some driving skills and capabilities of older operators of commercial motor vehicles. However, commercial drivers do not have the freedom private motorists have to make similar adjustments in when and where they drive. Job requirements, particularly schedule-adherence, make it difficult to do so. Some older commercial operators, because of seniority, can select shorter and safer runs. It is also possible, however that some may select higher paid but more arduous runs to maximize salary and pension payouts.

Older operators of trucks, buses, general aviation airplanes or ships do not appear to present a significant safety problem at this time. Typically, they maintain their performance levels by using their experience, automation of some activities, streamlining of tasks, and accommodation. The vast majority of older commercial operators retire responsibly, before medical conditions or capacities become an issue. As seen in Table 2, only a few transportation industries have

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18. Eberhard, John W., "Safe Mobility for Senior Citizens," Journal of the International Association of Traffic and Safety Sciences, Volume 20, Number 1, 1996.

19. The Safety Record of Heavy Trucks and Older Drivers: An Analysis of Five Years of Large - Scale Accident Data, Prepared for the Association of American Railroads by R.D. Mingo and Associates, January 1996.

operating employees above the age of 65 in significant numbers. Two exceptions are bus operators, 8.2 percent, and taxi/limousine drivers, 10.8 percent. No significant increase in crash rates has been attributed to older operators in these groups.

Shortages in the number of new qualified truck drivers may motivate motor carriers to keep their existing qualified drivers. Improvements in truck technology support the continuation of driving. Notable improvements include lowered cab vibration, noise, temperature extremes, and fumes. But because of these physical improvements, drivers can potentially (if not legally) drive longer - hours and at faster speeds. Increases in the work day can interfere with circadian rhythm with resulting sleep loss and fatigue-related disruptions. Sleep and fatigue related problems are known to increase with age. These environmental conditions may fall more heavily on older drivers.

Some maritime operators are active into very old age. The maritime environment is often physically stressful and mentally demanding. Individuals working on small commercial and fishing vessels often face the most arduous conditions. The types of safety risks that older operators face under these conditions are not completely clear.

2.2 CRASH INVOLVEMENT

2.2.1 Private Motorist

On a per-licensed driver basis, older drivers have a low crash rate compared to other age groups. In absolute numbers, older drivers have fewer crashes of all types. It is only on a per-mile driven basis that older drivers have relatively high rates of crash involvement. Undoubtedly, their self-restricted number of miles driven on average contributes to this. In fact, some quite elderly drivers may retain their licenses but drive few, if any, miles.

The reasons for the high crash rates per-mile among older drivers need to be explored. Involvement in property-damage-only crashes among older drivers predominate. However, fatal crashes increase steadily after the age of 75. It is unlikely that this increase is fully accounted for by loss of driving skill, or the inability to compensate for capability losses. Increasing physical fragility probably plays an important role in the increased fatality rate. We need to better understand the types of crashes older drivers are involved in to identify countermeasures.

Crash rates for older drivers are not evenly distributed across the various types of crashes. The sharpest increases with age involve intersection and crossing-path situations, where older drivers must make complex maneuvers and interact with opposing traffic. These include turning accidents (both right-and left-turn) particularly in urban areas, and lane-change accidents on 2-lane rural freeways. Older drivers are also over-involved in accidents at stop signs where the driver has stopped at the sign and then proceeded to pull out in front of another vehicle. [20] This

20. Human Factors Research in Highway Safety, Transportation Research Circular 414, National Research Council, Washington, D.C., Sept. 1993, p. 37.

may be due to the fact that older drivers have more difficulty perceiving and judging the dynamics of traffic movement and performing cognitive tasks with time constraints. Even if programs aimed at maintaining safe mobility succeed in lowering crash rates in the future, older drivers will be involved in more crashes on an absolute basis. This is simply the result of a growth in the elderly population. Population changes, particularly the aging of the 'baby boomers' and their extended longevity, will increase the number and proportion of older drivers, as seen in Figure 1 and Table 1.

2.2.2 Truck and Bus Drivers

There is no evidence that older commercial operators of trucks and buses are disproportionately represented in crashes. However, FHWA investigations found that when older operators were involved in crashes, cognitive factors were more likely to have played a role. Cognitive factors cited as significant in crashes were errors of omission (failing to take some action), and inattention.[21] Some commercial operators may have a problem of failing to commit undivided, concentrated attention to the driving task. One estimate[22] is that 60 percent of crashes involving older drivers occur because of cognitive factors. Another[23] is that 25 to 50 percent of crashes are the result of driver inattention. Inattention is also a likely culprit in many rear-end collisions, since drivers have better sensitivity to movement toward them as opposed to away from them. This indicates a reduced role of perceptual abilities [24]. The literature on aging, and on older driver decision making, selective attention, and attention sharing, indicates that capacity limitations exist in older adults. Age-related performance differences are even more substantial under demanding circumstances.

2.2.3 Aircraft Pilots

In aviation, there is some evidence that Class II and Class III (defined in 2.3.1) pilots have more fatalities at older ages. In the age category 65-69 they had higher crash rates than pilots aged 60-64. However, pilots between the ages of 63 and 69 generally have lower crash rates than pilots in their 30's.

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21. Fell, J. C. 1976. A Motor Vehicle Accident Causal System: The Human Element. *Human Factors*, 18, 85-94.

22. Malfetti, J. L. and Winter, D.J. 1986. Drivers 55 Plus: Test Your Own Performance, AAA Foundation for Traffic Safety. Washington, DC.

23. Shinar, D. 1978. Driver Performance and Individual Differences in Attention and Information Processing: Volume I. Driver Inattention. (Tech. Report DOT HS 8-801819) Washington, DC: US Department of Transportation, National Highway Traffic Safety Administration.

24. Staplin, L. And Lyes, R.W. 1992. Age Differences in Motion Perception and Specific Traffic Maneuver Problems. Transportation Research Record 1325. Transportation Research Board, National Research Council, Washington, DC.

2.2.4 Maritime Crew

As with rail operators, no significant increase in marine casualty rates have been attributed to older maritime crews. But in this industry changes in the availability of qualified workers, economic conditions, or patterns of retirement, can influence the sheer numbers of older workers. To the extent that these changes occur it will be important that monitoring for safety take place.

2.2.5 Recreational Boating

There is no evidence of increases in boating mishaps with age. But, as with other transportation activities, the age of individuals engaged in recreational boating will increase. The safety implications must be monitored.

2.2.6 Rail Crew

There is no evidence that older rail crews presently exhibit any special safety problems. Most rail workers come under a formal retirement system which results in few, if any, operating staff remaining at work after 65. No significant increases in rail crash rates have been attributed to older operators. However, changes in economic conditions, and in particular changing patterns of retirement, might affect the absolute number of older rail workers.

2.2.7 Pedestrians

Pedestrians aged 70 and higher represented almost 9 percent of the population, but accounted for 19 percent of all pedestrian fatalities in 1994. The death rate for this group was higher than for any other age group -- 4.36 per 100,000 (vs. 2.1 per the overall population). The safety of older pedestrians presents a significant challenge to the Department. (However, pedal cyclist fatalities for persons over age 70 were not anywhere near as significant, with death rates of 1.50 to 1.81 per million of population.)

2.3 MEDICAL REQUIREMENTS FOR LICENSURE

The medical requirements for licensure vary greatly among the different modes of transportation. There is still comparatively little scientific and epidemiological data to document the role of medical impairment (not including substance abuse) as a contributing factor to crash rates. (For these and other reasons, medical standards have evolved over the years based almost entirely on empirical evidence and clinical experience rather than on rigid scientific methods of experimentation, analysis, and evaluation.) Despite these drawbacks to quantifying the role of medical impairments, licensing agencies must establish regulations governing safe operation of all transportation modalities. In recent years, a renewed interest in medical impairment has surfaced because of the attention now given to commercial operators.

Operator evaluation should be based on functional capability to operate a specific vehicle under certain circumstances and not on simply the diagnosed condition or disorder itself. In this context, chronological age is not a good indicator of functional capability, but chronological age may be one component of a screening process based on functional capabilities. Summarized below are the medical requirements by each transportation modality. (All commercial operators are also subject to statutory drug and alcohol testing.)

2.3.1 Federal Aviation Administration (FAA)

- First Class Medical Certificate. This is the highest class of medical certificate and is needed for operations that require an airline transport pilot certificate (this includes all pilots who command the plane in operations conducted under air carrier rules). This certificate is valid for six months. A complete physical exam is needed and an electrocardiogram (EKG) is needed on the first exam after age 35. At age 40, an EKG is needed on an annual basis. Both vision and hearing testing are done for this certificate.

- Second Class Medical Certificate. This medical certificate is needed for a commercial pilot certificate (all commercial pilot duties other than those that require an airline transport pilot certificate). This certificate is valid for one year. A complete physical exam is needed. There is no EKG requirement. Both vision and hearing testing are done for this certificate.

- Third Class Medical Certificate. This medical certificate is needed for all general aviators. The certificate is valid for 36 months for those under the age of 40. Over that age, the certificate is valid for 2 years. A complete physical exam with hearing and vision testing are needed.

Air Traffic Controllers are required to undergo periodic medical examinations.

2.3.2 Federal Highway Administration (FHWA)

The requirement for a commercial driver's license (CDL) for truck drivers (greater than 26,000 pounds) and bus drivers (carrying 16 or more passengers) is a self certification that they have met the Federal physical qualifications for interstate operations every two years. If the driver remains intrastate, the Federal requirements do not apply. There can be no impairment with power grasping or limb defect. Drivers can not have diabetes mellitus that require the use of insulin nor can they have any history of seizures. Vision, hearing, drug, and alcohol testing are also required.

2.3.3 National Highway Traffic Safety Administration (NHTSA)

NHTSA has no requirements for private drivers. Licensing procedures are administered by state governments. Significant variability exists from state to state. Applications for new, renewal, and transfer licensure require personal identification information; questions are asked about the

presence of certain medical conditions or signs and symptoms that may be indicative of certain conditions. The most common driving restriction is for vision problems.

2.3.4 United States Coast Guard (USCG)

Certification is required for most merchant mariners. A complete physical examination is required every five years for officers and qualified seamen. All mariners must be able to climb steep or vertical ladders, and enter or exit enclosed compartments through hatches or doors with sills up to two feet. Vision, hearing, drug, and alcohol testing are also required. Licensing requirements also vary with size and type of vessel. There are currently no medical testing requirements for recreational boaters.

2.3.5 Saint Lawrence Seaway Development Corporation (SLSDC)

The corporation has no industry medical requirements. For hazardous materials operators, the SLSDC uses FHWA requirements.

2.3.6 Federal Railroad Administration (FRA)

The medical requirement for certification includes testing for vision and hearing acuity. For distant viewing, visual acuity shall be at least 20/40 (Snellen) in each eye with or without corrective lenses; distant binocular acuity of 20/40 (Snellen) in both eyes with or without corrective lenses. Hearing loss in the better ear can be no greater than 40 decibels at 500 Hz, l000 Hz and 2000 Hz with or without the use of a hearing aid.

2.3.7 Federal Transit Administration (FTA)

The medical requirement includes only statutory drug and alcohol testing performed by the transit operator. All those who operate vehicles carrying 16 or more passengers must have CDLs -- this is the vast majority of transit providers.

2.4 OVERVIEW OF CURRENT RISK MANAGEMENT STRATEGIES FOR COMMERCIAL TRANSPORTATION

Governments and industry have established monitoring and evaluation systems to manage risk and assure operators are capable of performing at or above certain minimum standards. These minimums are usually limited to capabilities that are easily measured. An example of this is the widespread use of conventional static vision testing for driving licensure as opposed to dynamic vision testing which is more difficult and costlier to perform.

Evaluation systems vary widely by mode, medical requirements, enforcing authorities, proficiency testing, and by monitoring through authorities. The most comprehensive risk evaluation system is

found in aviation; in contrast, recreational boating is the least regulated, least studied mode. Systems for certain transportation modalities are described below.

2.4.1 Aviation

The aeromedical certification system is the most highly developed and sophisticated program of its type in transportation. Aviation medical examiners are medical doctors. They are required to take periodic aeromedical related training provided under the auspices of the FAA. Further, these examiners are often aviators themselves, which gives them a special understanding of the relationship between medical conditions and flying.

Pilots are required to demonstrate a certain level of proficiency to acquire an airman certificate. They must continue to meet performance requirements, as well as the medical requirements listed above, in order to retain the right to fly using their airman certificate. Airmen may not act as pilots in operations conducted under air carrier rules after reaching 60 years of age. There is no age restriction for general aviation pilots or other commercial pilots as long as they maintain their medical certification and licensure. About 5.3 percent of commercial pilots and 7.7 percent of general aviation pilots are over 65.

The Federal Aviation Administration has in effect a rule barring pilots over 60 from piloting aircraft operated under air carrier rules. This has been a source of considerable debate over many years, in part for the reasons cited above. After much public comment, the FAA recently decided to keep this rule in effect, to maintain confidence that existing levels of safety will be preserved. Although there are undoubtedly many pilots over 60 perfectly capable of flying those aircraft in safety, it is not yet possible to pinpoint with certainty those few who could not. For commercial operations, where there may be many lives at stake, the Department must adhere to a very high standard for safety.

Air traffic controllers must undergo periodic medical examinations. They have age-based mandatory retirement. After 1997, an air traffic controller must be separated from employment before reaching age 56 (although waivers can be granted for special skills).

2.4.2 Highway

In the surface transportation industries there are differences in levels of rigor of proficiency and medical assessment. Commercial truck and bus operators must maintain a current Commercial Driver’s License (CDL). If the driver operates in interstate commerce, the Federal Motor Carrier Safety Regulations require a medical examination as noted above every 2 years. There is no minimum age requirement for obtaining a CDL other than the state driving age, but interstate drivers must be at least 21. Defacto minimum and maximum age requirements, where they exist, are a function of individual company and or union policies. Major trucking, and major urban transit systems often have quite rigorous procedures for monitoring their operational personnel. About 2.3 percent of truck drivers are over 65.

School bus operators are required to have a CDL and thus need medical examinations every 1 or 2 years, depending on the state. Most operators of transit vehicles are required to have a CDL. Taxi operators, contract bus operators, and independent owner operators often have only the most rudimentary company monitoring programs. Further, the level of surveillance of these groups, provided by state and municipal government, varies widely. About 8.2 percent of bus drivers are over 65 and 10.8 percent of taxi operators are age 65 and older.

2.4.3 Marine

In maritime industries, licensed ships officers do not have an upper age limit and are required to renew their licenses every five years and radar recertification for deck officers. Depending on the vessel and work function, they must undergo basic medical examinations. However, periodic retesting varies and is employer-driven. Approximately 3 percent of ship captains and mates are over age 65.

2.4.4 Rail

In the railroad industry, the retirement age is largely determined by the Railroad Retirement Act. The number of railroad engineers, conductors and yardmasters over 65 is less than 1 percent.

In summary, our screening and evaluation systems for commercial operators appear to be serving the population well with regard to age factors. There are still potential improvements that might be made. In the highway realm these improvements are being identified and evaluated. FHWA has a series of studies underway to reassess current medical requirements.

Also, a relative risk scale is currently being developed by the American Association of Automobile Medicine (AAMVA) and NHTSA that could support a set of national criteria for determining licensure. This scale would provide a list of medical conditions that may impair operators of personal and commercial highway vehicles. It would also propose a method for assessing such conditions in relation to safe vehicular operation.

2.5 INTERNATIONAL PERSPECTIVES

It is illustrative to examine the risk associated with motor vehicle operation and licensing practices and age across countries. The risk of traffic fatalities is higher for older adults. The overall road traffic accident fatality rates show that older adults (operators, passengers and pedestrian) are at higher risk in virtually all countries examined. This is illustrated in Figure 5. This figure also shows that the United States ranks 6th in traffic fatality rate for older adults of the 21 nations examined in terms of relative risk of traffic fatality. As shown in Figure 6, within the older adult population, those aged 75 and older have a higher risk of fatality than those 65-74 in all of the 22 countries examined . Older adults have a substantially greater risk of becoming pedestrian fatalities than the population at large for the 18 countries examined, as illustrated in Figure 7.

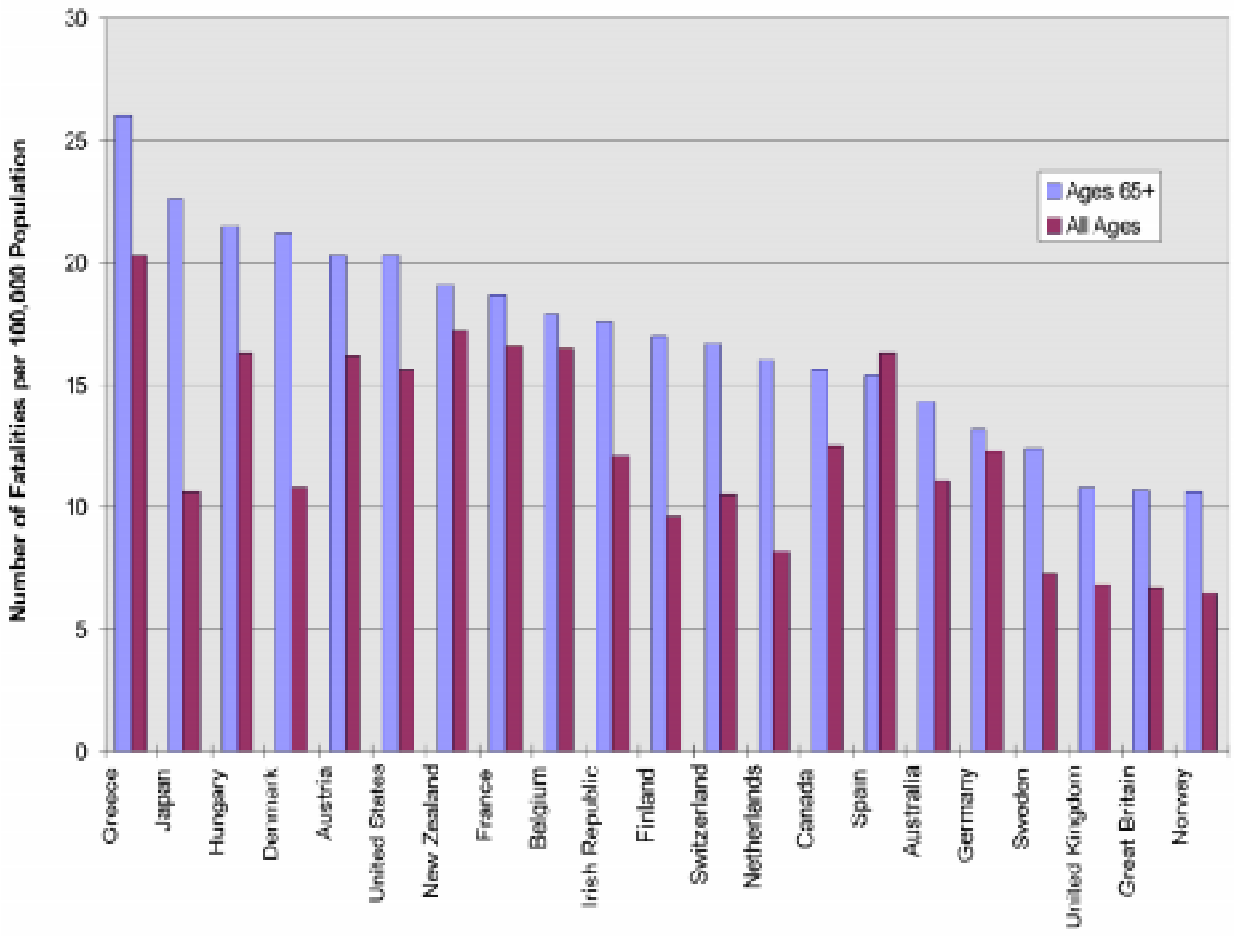

Figure 5. Road Accident Deaths by Age Group and Country (International Comparisons of Transport Statistics 1993)

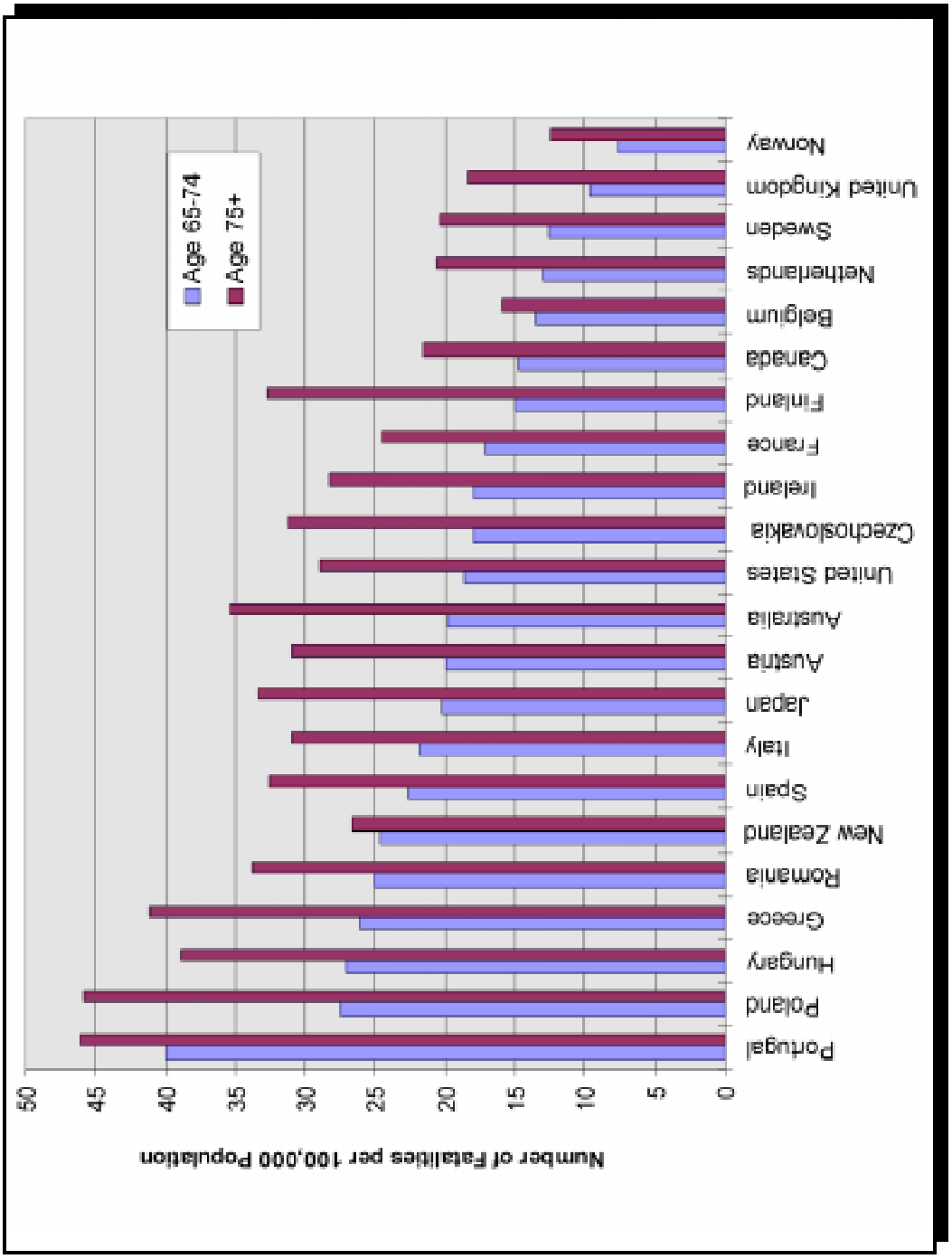

Figure 6. Fatality Rates for Older Drivers and Passengers by Country (1991 Statistics of Road Traffic Accidents in Europe)

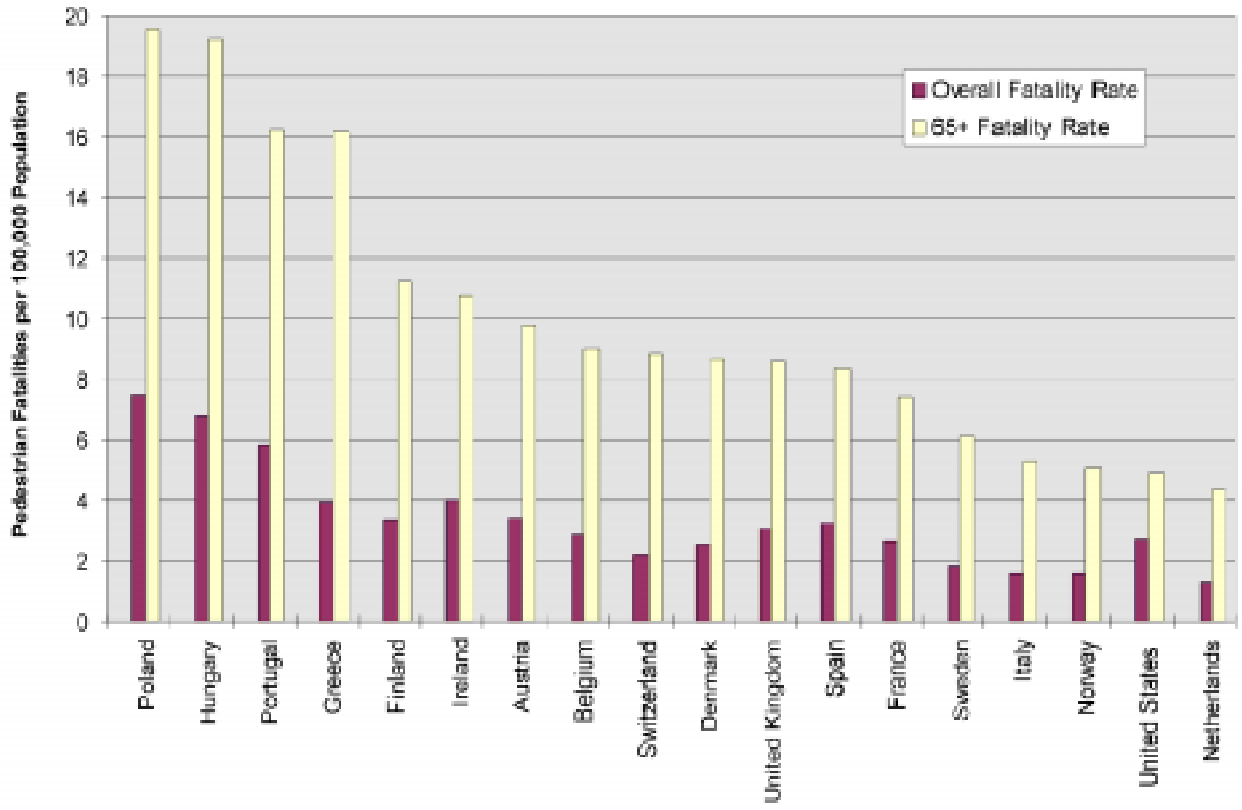

Figure 7. Pedestrian Traffic Accident Fatality Rates, Overall and Age 65+ by Country (1991 Statistics of Road Traffic Accidents in Europe)

The most common way to license motor vehicle operators is to grant what is essentially a lifetime license with periodic renewal requirements. There is an emerging international trend to review motor vehicle licensing practices in relation to increased age of the operator as may be seen in Table 5. A number of jurisdictions either terminate licenses or require a special license renewal triggered around age 70 accompanied by some level of medical review (i.e., Denmark, Finland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Portugal). If the results of the age-triggered procedure permit vehicle operation, the older operator is issued some variant of a "term" license which is valid for a defined time period. Several countries which currently issue life time licenses are discussing some form of an age-based review process or introducing restricted licenses as part of their motor vehicle licensing procedures. Germany is debating the former and New Zealand the latter. Other countries have recently added additional types of medical review for older operators (United Kingdom, Sweden for 'heavy' vehicles).

3. SAFE MOBILITY, FOR LIFE

3.1 BACKGROUND

One of the primary forces contributing to the vitality of our Nation is its high degree of personal mobility. As Americans we expect to travel when and where we please. And we expect to travel how we please, whether it is in our own car, or even our own boat or plane, or by using a transportation service we independently select from an array of choices. The United States now has more cars than licensed drivers as well as 11.4 million watercraft, and 170,000 airplanes. All these conveyances are for personal mobility (for transportation and/or recreation) in one form or another.

With the exception of people with very low incomes, the primary constraint on full mobility in our personal lives comes with the onset of physical or mental problems of sufficient severity to compromise the safe operation of a vehicle. For the vast majority of people this occurs through the processes of aging outlined above. Personal mobility is so taken for granted that for many its restriction becomes the true point at which the quality of life begins to deteriorate. Independent choice of time and destination then narrows. In areas where public transportation services are unavailable or unsatisfactory, many must ask for transportation from family or friends to get to such necessary destinations as grocery stores, clinics, places of worship, and social engagements. The isolation thus resulting has not been formally linked to effects on health and well-being, although the current thinking is that social interaction plays an extremely important part in older people's overall well being. This linkage is becoming the subject of a national dialog, and will be discussed below.

This emphasis on mobility presents several public policy contrasts:

- It is in the national interest to keep people operating their personal vehicles (cars, boats, planes) as late in age as possible for quality of life reasons -- yet we do not want that operation to unnecessarily endanger the individual or the public.

- It is also in the national interest to maintain the productivity and value-added of those who operate vehicles commercially, as long as it is safe -- yet we must recognize the higher public risks presented by those operating commercial vehicles.

- Most individuals, who detect their faculties for safe operation deteriorating, withdraw in responsible ways and require no action from authorities -- yet some continue to drive when they should not. A system is needed to protect against such drivers.

- The public believes that the licensing systems run by the individual states screen out unsafe operators of private motor vehicles -- yet states are reluctant to place special conditions on drivers on the basis of age for fear of political consequences or violations of

civil liberties. Individuals who voluntarily seek information to determine if their reduced capabilities will result in unsafe operation can find little objective guidance or information on options open to them.

- A number of agencies of the federal government have common interests regarding mobility as evidenced through programs that deal with both aging and transportation-- yet these programs have never been formally coordinated. A similar situation exists within DOT and the same is also true for many states.

These three considerations: safety, individual personal mobility, and facilitating the eventual transition to mobility alternatives define a strategic planning goal for the nation's transportation system for older adults: *Safe Mobility, For Life*. To achieve this goal a number of proposals are described below. These proposals would support the attainment of other DOT missions as well. The goal can best be achieved not through large, new infusions of federal funding but with better coordination of funds already available at the community level, along with increased education of the public. *Safe Mobility, For Life* is characterized by the following precepts:

- Keep people operating vehicles as late in life as possible, as long as they can do so safely, particularly in areas with limited transportation alternatives.

- Promote technologies that support those individuals with age-related deficits so they can continue to operate safely longer.

- Improve the public and private screening and evaluation systems which provide the means to determine when older adults can no longer operate safely.

- Bring new emphasis to the provision of non-driving alternatives for the transportation needs of older adults.

- Educate the public on what they can do to maintain operational safety, and to prepare for older age without driving.

3.2 NON-DRIVING MOBILITY ALTERNATIVES

3.2.1 Planning for Lifelong Mobility

Mobility for the elderly should be integrated into planning at all levels: individual; community; and state. This extends to the statewide and urban transportation planning processes carried out by state and local agencies, including metropolitan planning organizations (MPOs).

3.2.1.1 The Individual Level - There is a need to educate the public that they need to plan for their own mobility in later life, including the site of their retirement, just as they plan their estate and retirement program. Such plans should consider a likely shift from independent individual

transportation to transportation alternatives which make use of friends, relatives, and public providers.

3.2.1.2 The Local Level - Local agencies, including the MPOs should identify a goal for overarching community mobility and recognition of the need to provide comprehensive transportation services for older adults. Transportation plans should be evaluated on the extent to which they enhance elderly-sensitive transportation in community design (e.g. walking or biking to nearby stores or transit stops).

3.2.1.3 The State Level - The DOT and HHS, and a number of other Federal agencies fund comprehensive programs that provide transportation services to older adults. With the exception of the work of the DOT/HHS Coordinating Council on Human Services Transportation, very little of the delivery of this funding is jointly planned and coordinated at the state level. Considerable improvements in the efficiency with which these funds are used would be possible were the agencies to better coordinate their planning for the transportation of older adults. The recent movement toward the appointment of coordinators and task forces at the state level, however, has enabled a number of states to coordinate and maximize the joint use of these funds.

3.2.2 Non-Driving Mobility Alternatives

Many forms of transportation service for the elderly exist, but they are frequently fragmented, uncoordinated, and not universally available.

3.2.2.1 Public Mass Transit - Although only about three percent of trips by those over 65 are by transit, it often represents the only mode available to many older Americans. Thirty-two million older adults increasingly rely on transit as their driving ability decreases with age. Transit offers a practical way for these people to maintain mobility, by providing low cost access to community and social services, economic activities, and medical care. The concept of public transportation for older adults needs to be revisited, with added emphasis on service, security, and accessibility, to overcome the view of transit as an inferior transportation alternative. Another emerging problem is that in some areas, the Americans With Disabilities Act paratransit requirements have resulted in elimination of the demand responsive services for older adults which used to be provided.

Although more than 1,100 rural transit operators exist, their ability is limited in providing service to their low-density areas, in providing demand responsive service, and in providing the level of perceived security required by older users. Reduced transit funding for rural operators could force older adults into isolation or out of their homes into publicly funded care which is far more expensive than door to door bus trips to the market or to the doctor's office. A proposed solution to the reluctance by older adults to pay out-of-pocket taxi costs would be a subscription system which could lower costs and "mainstream" taxis as a supplemental part of the rural transportation system.

3.2.2.2 Community Based Systems - Thousands of communities operate systems with support of FTA and HHS funding. Nearly 3,700 transportation providers operate vehicles obtained through FTA's Section 5310 program for the elderly and persons with disabilities. This assistance totaled $59 million in fiscal year 1995. Because the program provides capital assistance only, providers obtain funds to operate their vehicles from a variety of other sources. For agencies principally serving the elderly, about 43 percent of operating assistance comes from state and local governments. Human service agencies provide another 36 percent. In particular, elder transportation services get 20 percent ($64 million in fiscal year 1994) of their operating funds from Older Americans Act programs.[25] The Medicaid program provides 16 percent of total operating funds for all Section 5310 providers.

The Section 5311 program provides capital and operating funds for transit services in rural areas with populations less than 50,000. The FTA distributes the funds to state DOTs, which in turn allocate them to local providers. About $133 million in assistance was given to rural providers in fiscal year 1995. Section 5311 funds over 1100 providers -- 25 percent of them operate only 1 or 2 vehicles, and less than one out of three operate more than 10. While older adults represent only 18 percent of the rural population, they represent 36 percent of Section 5311 riders.

3.2.2.3 Informal Systems (Family and Neighbors) - Informal support currently provides the bulk of the local transportation service for older adults. Many places of worship, senior centers, hired drivers, and volunteer organizations provide transportation services, but most frail elderly (not in institutions) are transported in family automobiles. The next aging cohort may be more transportation disadvantaged because it may lack the help now provided by adult children. It may be unrealistic to continue to rely on family and neighbors as mobility providers in the future. Spouses and daughters have been the traditional care givers. In the future, spouses and daughters able (and willing) to take on transportation and care duties may be in short supply due to smaller family sizes, higher divorce rate, and greater proportion of women in the workforce. One countervailing trend is the emerging willingness of employers to accommodate the caretaker role of their employees.

3.2.2.4 Other Mobility Assets - The *young*-old often provide transportation services for older segments of the elderly population. For some, this may provide part-time, low wage jobs to supplement their retirement incomes, or they may work voluntarily, but as pointed out in Section 1.3, the need for transportation may in turn become a barrier to getting to these jobs.

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25. The Older Americans Act (OAA) established the HHS Administration on Aging (AoA). The Act authorizes funding for transportation services for persons age 60 and older under Title III-- State and Community Programs on Aging. The AoA distributes Title III funds to the State Units on Aging, which in turn provide them to the Area Agencies on Aging and Title VI organizations. These agencies then award grants or contracts to local service providers to cover their operational and capital costs.

3.2.3 Initiatives for Consideration

A number of initiatives can be considered to meet the substantial spectrum of concerns for older adults. These initiatives were developed in part from the proceedings of several groups, including the five Expert Panels mentioned previously, the Steering Committee for the ITMS project, and the previous work of the TRB's Panel on Aging.

3.2.3.1 Better Coordination at the Federal Level -

- **Upgrade DOT/HHS Coordinating Council of Human Services Transportation**. Nine Federal agencies fund transportation as part of 90+ programs, many of which include the elderly. Most of the funding is at HHS, which works with the Department of Transportation through the joint DOT/HHS Coordinating Council on Human Services Transportation. The Council has few dedicated resources of its own, with the professional members sharing their Council duties along with many others. The Council is expanding its current joint efforts to the promotion and coordination of transportation resources of other relevant Federal agencies that sponsor transportation (e.g., Departments of Veterans Affairs, Labor, and Housing and Urban Development).

- **Sponsor International Cooperative Program**. Since the entire industrial world is aging with many countries doing so at a faster rate than the United States, safe mobility for older adults is a world-wide concern and there may be better solutions developed through international cooperative programs. A world-wide conference, similar to the 1988 Transportation Research Board's "Transportation for an Aging Society" would help to identify and evaluate international solutions. That study occurred before the numerous activities on the issues were undertaken by the U.S. DOT, other government agencies and the private sector. An international study on transportation for an aging society is required that would both update the 1988 TRB report and greatly extend it by incorporating the international perspective.

- **Public Awareness Programs**. Work with Administration on Aging (AoA) to develop educational programs on mobility. Redefine retirement planning to include mobility planning, promoting an awareness of the importance of the provision of safe mobility at the community level. Work with the AAMVA Public Affairs and Consumer Education group to make older adults and the general public more aware of the issues and solutions for safe mobility. Review what public and private sector networks exist by which to get materials on safe mobility to older adults.

- **Web Site**. Develop a home page on the world wide web for transportation issues, and link to Senior Net, AARP, etc. Include latest developments in technology, medical issues, best practices in the communities for mobility, grants for new pilot projects, etc.

3.2.3.2 Better Coordination and Promulgation of Best Practices at the State and Local Level - Transportation programs for older adults are for the most part Federal-agency specific and use of funds is narrowly proscribed. A number of states (e.g., FL, NC) have established active coordinating authorities (e.g., councils, task forces) by which to take advantage of different funding programs with varying results. In general, there is a need to find better ways to coordinate services and combine funds from different agencies, which would be encouraged with more interest being displayed at the Federal level (e.g., more support for coordinated planning, indication of more willingness to allow waivers and exceptions if it leads to more cost effective service and higher utilization rates).

- **MPO Best Practices**. Identify best practices among MPOs for incorporation of mobility alternatives and coordination for the elderly within their communities. Promote the concept of mobility managers and mobility counselors as an adjunct to state coordinating agencies. At the local level, MPOs should have representatives from the elder community on their advisory committees and review the MPO's Transportation Plans and Programs. There are hosts of sources for non-driving mobility alternatives that would be considered in a comprehensive community plan. There are formal systems, such as those sponsored by DOT, HHS, and other agencies, and informal systems, as provided by family and neighbors, religious organizations, senior centers, and volunteer organizations. There is a need to provide training and technical assistance for state and local planners on older mobility issues.

- **Stimulate Replication of the Most Effective Systems**. Evaluate existing providers of mobility services around the country for their strengths, weaknesses, and gaps in service. Evaluate which models perform best (e.g., Portland, ME; Columbia, MO; Wichita, KS; Eugene, OR) and issue reports on best practices.

- **Increase Technical Assistance**. Increase FTA and FHWA technical assistance, to make transportation organizations and their customers more aware of how to improve mobility alternatives for older adults in a cost effective manner. Consideration should be given to research and pilot programs. In providing assistance, FTA should include advice on how to maximize the use of funds.

- **ISTEA**. In the *ISTEA* reauthorization process, create provisions to assure local and state planning for the mobility of older adults, allowing the transportation system to change in response to the growth in the older cohort. This planning should involve coalitions of those interested in aging issues. Also included should be provisions to expand eligibility for partnering of mobility networks and systems.

- **Promote More Collective Use by Community Providers**. Review DOT, HHS, and other regulations that inhibit participation by and full transfer of funds to the community providers (particularly HHS funding programs which are never fully subscribed). Based on this review, the Cabinet Secretaries could indicate areas where they would be willing

to grant waivers and exceptions, to provide more cost effective transportation services and higher utilization rates.

3.2.3.3 **Promote Coordination With Industry** - Establish a review team to consider what new forms of collaboration are possible with other stakeholders (e.g., insurance companies, advocacy groups, university centers, employers) to enhance non-driving mobility alternatives. Review prospects for establishing an industry advisory group, or alternatively, initiate a separate subcommittee under the existing Federal Advisory Committee to evaluate key issues regarding elderly mobility alternatives that need to be addressed. The committee members should consist for example of members from the President's Committee on Employment of Persons with Disabilities, AARP, and other prominent groups.

3.3 IMPROVING OUR IDENTIFICATION AND EVALUATION SYSTEMS

The highest form of personal mobility is achieved when people are getting around on their own. Thus, as a matter of policy, when transit is not an option, we want to keep people driving autonomously as long as they can do so safely. As noted in Section 2.1.1, contrary to stereotypes, the evidence shows that in the aggregate, older motorists are not necessarily dangerous. Many withdraw from driving when they fear their deficits are impairing their performance. Unfortunately, there are few places they can go to get guidance as to what their relative competence is, and how to maintain it at a safe level.

A policy of keeping private motorists driving their cars as late in life as possible, however, establishes two corollary requirements: 1) finding improved ways to identify and regulate drivers who may be or are becoming a problem; and 2) developing ways of evaluating who has the capacity to drive safely, and if possible rehabilitating them so they can continue to drive (even under constrained conditions).

3.3.1 Improving Our Systems for Identifying Problem Operators

With the number of older operators growing, there is a need to develop more economical, reliable, and uniform screening techniques that can be applied to as many people as possible. Those screening techniques should identify those who may be, or are becoming problem drivers. Once identified there should be a procedure to refer problem drivers or potential problem drivers to the appropriate professional or agency.

3.3.1.1 Public Sector Identification Systems - Today most problem drivers are identified somewhat haphazardly and belatedly by their crash experience; traffic citations; reporting by a physician, police officer and/or family member; and their license renewal applications. There is little uniformity across states. There is also a need to shift from current adversarial approaches to more supportive and dignified approaches. As an example, Oregon has developed a system for identifying problem drivers in which older adult drivers can meet with a counselor who helps them to determine the extent of their driving capabilities. There is also a need to initiate programs

that will teach people in the medical and social services field to look out for impairments which will lead to unsafe driving, and recalcitrant problem drivers.

3.3.1.2 Private Sector Identification Systems - Peer reporting and that of outside observers provides some checks on age-related performance among commercial operators. However, such reporting cannot be relied upon as a significant factor. A number of companies put *800* numbers on the back of their trucks (*How's My Driving*) to encourage motorists to report bad, as well as good, driving practices.

3.3.1.3 Family/Social Systems - Often it is a family member who identifies problem drivers and generally helps the individual to recognize his/her deficits. Sometimes family intervention is unsuccessful. There is a need to establish guidelines for families on how to aid an older adult in making the right choices. This need is particularly important for drivers who are cognitively impaired.

NHTSA is developing ways to assist family members and social agencies in recognizing impaired drivers. Families are best positioned to identify problem members, but not necessarily to act. Psychologists contend that only families can control cognitively impaired drivers. However, they need education and a socially responsive support system. Specifically, the programs will inform older adults, their spouses, their children, or others in the health and social support system to recognize critical deficits related to driving; and, if deficits do exist, where they can go to seek help.

3.3.1.4 Identifications at the Individual Level - Some individuals, facing the reality of the onset of serious disabling conditions, withdraw from driving immediately. Others withdraw from driving gradually and responsibly by constantly making strategic decisions. These strategic decisions involve selecting the times and places to minimize the effects of their deficits. As noted above, in some cases, individuals should withdraw and don't, while in others drivers retire perhaps before they have to. Hence, there is a need to improve on programs to facilitate self-assessment, and to develop remedial tools older drivers can use to evaluate their own abilities for safe vehicle operations. There is also a need for programs by which older motorists can maintain or regain their proficiency in their operating skills, or to provide for the transition to alternative transportation.

3.3.2 Developing Better Assessment Tools

The above identification techniques should quickly and economically identify potential problem operators for whom more extensive evaluation is needed. The conditions being evaluated may not be clearly black and white; rather, they exist along a continuum from the direct observation of physical problems, which prohibit safe vehicle operation in clear and obvious ways, to the measurement of perceptual and cognitive problems which are linked through inference to a high likelihood of crash involvement, and which require specialized testing procedures.

3.3.2.1 Public Sector Evaluation Systems - There is some variation among states in procedures for evaluating the proficiency of older operators. Other than static visual acuity testing, objective criteria are scarce. State DMVs actually remove relatively few people from driving (less than 10 percent of older drivers lose their licenses), and among states DMVs vary in their failure rates (as stated during the Management Expert Panel). NHTSA has research underway to develop new road and other tests focusing on disabilities prevalent among older adults. Most states and provinces are considering or actually privatizing license examination requirements. This trend in readjusting the licensing process could provide the opportunity to upgrade driver re-examination requirements, providing costs can be made reasonable.

3.3.2.2 Private Sector Evaluation Systems - Some private companies have innovative programs of their own. The American Occupational Therapy Association and the Association of Driving Educators for the Disabled are leading the way in improving the evaluation and rehabilitation of functionally disabled drivers. Companies with a large number of commercial operators are naturally more likely to have more extensive medical programs. However, there are no standard practices among even the largest companies. Simulators, developed in the private sector, may have the potential to be an aid in evaluation.

3.3.3 Role of the Health Care Community

At present, there is concern about how to optimally involve the full spectrum of health care professionals in dealing with the identification and treatment of medically impaired motorists. The role of medical conditions and functional disabilities in the safe operation of vehicles is not fully understood among researchers or within the professions. Also, the costs involved in assessing and treating these conditions are extensive. For example outpatient costs for an assessment by an occupational therapist can vary greatly in the U.S., from $200 to more than $1,000. The magnitude of these differences suggests that professionals are taking widely different approaches to assessment and retraining. The disparity indicates the need to make the process more efficient, tailoring assessments to the identified conditions (e.g., stroke), or cataloging best practices and assessment tools, and possibly certifying those who perform the service.

As part of the assessments, health care and driving licensing professionals must agree on what levels of operation are safe, if any. They must also decide whether the operator can be made more safe through training and/or rehabilitation, or at what level of proficiency cessation must be prescribed. Many states allow no discretion in the licensing review process with respect to certain diseases.

Initiatives in this area should be tied to the concept that mobility will be maximized when health care professionals work in concert: physicians, optometrists, physician's assistants, psychologists, nurses, nurse practitioners, and occupational and physical therapists. It has been expressed that the primary need of physicians is guidance on what medical conditions are of concern, and a better understanding of what can be done. NHTSA is working on the first issue through its Medical and Functional Standards Driving Project. With respect to the latter, it plans

to develop systems for educating physicians and health care professionals regarding standards of care, what resources are available, and how to activate them. These plans are discussed further below.

3.3.3.1 Reporting Deficiencies - The health care community is not clear or in agreement as to its responsibility to inform the state of those operators who are incapable or unwilling to adhere to safe operating practices (see Section 1.5.2.1). For these purposes, a reporting system that protects those reporting needs to be developed and implemented. The presence of such a requirement in Pennsylvania has led to 45,000 reports annually (according to Expert Panel). One initiative in this area would be to develop a model reporting system.

3.3.4 Identification/Evaluation of Commercial Operators

As discussed previously in Section 2.3, the operation of commercial vehicles of all modes require medical evaluations, prior to licensure, and continuing evaluations for maintenance of those licenses. Generally, aviation examinations and those examinations required by the OMCS Regulations are more definitive and physician intensive. However, practices are not uniform, and physicians can be unaware of the full spectrum of specialists to whom they can refer their applicants when there is uncertainty about performance potential.

3.3.5 Present DOT Supporting Programs

NHTSA has under development more dignified and economical techniques for screening, some of which draw on the family and the community to identify those who should be evaluated. This includes developing new tests that focus on disabilities prevalent among older adults. It also has a research program underway designed to help the states determine who should and who should not be driving. Its focus is much more proactive than the traditional model and is designed to identify those who are at the threshold of being unsafe drivers or who have functional limitations that reduce their driving abilities. Under this program, screening and diagnostic assessment tests and other tools are being designed to determine who can compensate for those disabilities, who needs to be told to stop driving and, with the aid of other organizations, who needs help in transitioning to other alternatives. Built into the development is an extensive series of field tests to help ensure that older adults are not being discriminated against by the proposed measures.

3.3.6 Initiatives for Consideration

3.3.6.1 **Medical Practice Parameters and Guidelines** - Prepare a standard set of guidelines whereby physicians can consult with an authoritative source regarding diagnostic steps and definitive action to take. If a data base were to be established of medical practice parameters and guidelines (in the form of what is medically known as pathways), it could be used by physicians and all health care professionals. Development of these pathways would provide a practical way to diagnose and determine how severe a given medical condition or functional disability is, and its implications for driving or using other transportation facilities. The pathways would have to be

developed by selected medical specialists (e.g., geriatricians, ophthalmologists) and involve the appropriate professional groups (e.g., AAMVA, Association for the Advancement of Automotive Medicine, and the American Medical Association). Some states allow no discretion regarding certain diseases; others leave the discretion to the physician. To reflect the considerable variations among the states, the guidelines would have to be state specific.

There is thus a need to organize a multi-disciplinary team to develop a set of guidelines for the use of physicians and health care professionals as an authoritative source when conducting evaluations required for commercial licensure, as well as personal licenses in instances where medical examinations are required. In addition to improving the diagnosis, this guidance would establish a standard of care, which in turn would provide a cost control tool, and a legal defense for what the health care professional determined. It would also provide an educational way to explain to patients why the action prescribed is required. The decision-making algorithms could also reflect the risk assessments described above. Where computer aided information is unavailable, guidebooks localized for the state(s) where the health care professional is practicing would be necessary.

3.3.6.2 **Referral Data** - There is a spectrum of health care providers to whom physicians could refer their cases. These practitioners have the potential through training or rehabilitation to work with the applicant or reapplicant to remedy the conditions for which they were rejected, or declared marginal for continued licensure renewal (e.g., physical therapy to improve range of motion for truck drivers). A data base which lists health care practitioners specializing in retraining or rehabilitating operators, as well as their locations, would provide referral information as the natural next step in the treatment process. (The TRB Older Driver Resource Directory which is in the process of being updated could serve as such a data base.)

3.3.6.3 **Education of the Medical Community** - Develop training modules covering medical conditions and deficits experienced by aging operators, and the performance problems they pose. The full scope of medical specialization regarding older drivers and/or mobility alternatives is not widely studied among primary health care practitioners. To increase awareness, training modules - covering medical conditions and treatments and their implications for the driving performance of - aging operators should be developed and distributed to health care practitioners, and be included in continuing education curricula.

3.3.6.4 **Self Help Tools** - Give renewed emphasis to development of family as well as self assessment and remedial tools (e.g., AARP, AAA, and National Safety Council pamphlets). Using such tools, older adults, their family members, and social agency contacts can evaluate the driver's abilities to continue to operate vehicles safely, maintain their proficiency in operating skills, or transition to alternative transportation.

3.3.6.5 **Rehabilitation Best Practices** - Identify, develop, evaluate, and disseminate "best practices" for rehabilitation of drivers as identified and evaluated above. These rehabilitation

practices would be established as common elements in forward-looking rehabilitation programs. These would include driver training and vehicle modification programs for older adults as well.

3.4 POLICY RESEARCH

There are a number of issues regarding mobility for the elderly for which information is only fragmentary, and additional research is needed to support public policy decisions. For example, enhancing mobility alternatives represents a policy response to three issues of concern to the elderly: their quality of life; their continued safety and security; and their health care costs. This justification cannot be unequivocally made, however, without much more research.

NHTSA and HHS have an ongoing project on ***Mobility Consequences of No Longer Driving***, but more research may be needed to demonstrate how to overcome inappropriate consequences. FTA has funded a number of research efforts aimed at enhancing transit security. While these programs do not focus on the older user they do take a systems approach with regard to cost, staffing, and overall system function. These programs seek to enhance security through improved procedures and the use of new technologies. However, they are usually restricted to the portion of the trip provided by the transit system.

3.4.1 Linkage Of Mobility to Health Care, and Social Services, Costs

It has been suggested that mobility for older adults, i.e., their ability to get around, make social contacts, etc. may be related to their state of well-being and thus their health care cost. While the adverse health effects of social isolation have been documented,[26] we cannot yet document the linkage of increased health care costs to reduced mobility. To do this we must perform epidemiological studies of the impacts of reductions of mobility on interrelated factors such as health-related expenditures, longevity, and quality of life.

3.4.2 Influence of Mobility Alternatives on Driving Cessation

The provision of mobility alternatives can have two functions: enable individuals who have ceased driving or have never driven to maintain their mobility; and to allow those who are no longer comfortable as drivers to reduce this activity. Research to determine the extent to which the availability of mobility alternatives will effect an individual's willingness to reduce or curtail driving will allow us to gain an important insight into the efficacy of alternative mobility programs. The impact of modern communities, mail and delivery services should be taken into account. It is entirely possible that some of those too cognitively or physically impaired to drive may also be unable to use many alternative forms of transportation, particularly transit. Some may require travel training. These individuals may require a traveling companion to assist them in meeting their mobility needs.

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26. Olds, Jacqueline, Schwartz, Richard S. and Harriet Webster. Overcoming Loneliness in Everyday Life. New York: Carol Publishing Group, 1996.

3.4.3 Security Concerns of Older Adults

In spite of the fact that taxpayers invest billions of dollars per year keeping transit, para-transit, and other mobility alternatives in place, many elderly avoid them because they see themselves as potential targets for harassment, intimidation and criminal acts. These perceptions are often fed by rumor and or lurid news accounts of isolated incidents. The result is reduced mobility and a loss of access to vital activity centers for many seniors. Although significant work has been done to improve and maintain the security of some transit systems, little work has been done to examine elder security issues across all modes, including airports, ferry and multi modal terminals. Security concerns can also restrict older adults from walking and using their private vehicles at certain times of the day and at certain locations.

There is a need to determine the actual and perceived security of all transportation modes and their surrounding environment for all phases of the trip. For example, in the case of transit buses, the bus itself may be secure enough, but the exposure between home and the transit stop, or at the stop itself must be considered. From the patron's point of view, if there is insufficient security, the risk associated with the trip may be too great although some modes are ostensibly more secure than others. Based on such an approach, it should be possible to develop guidelines, procedures and technologies for better protection of older adults. It may also be possible to develop methods for fairly and accurately quantifying the risk of the trip in terms of security to respond to the fears generated by rumor and sensational news reports.

3.4.4 Initiatives for Consideration

3.4.4.1 **Conduct a Study of the Impacts of Reductions of Mobility** - Research the present national dialogue on the importance of social contact and independence to the state of well-being of older adults, and thus their health care cost. Determine through epidemiological studies the extent to which linkage exists between health care costs, quality of life and mobility, as described in Section 3.4.1. These studies will involve the impacts of reductions of mobility on factors such as health-related expenditures, longevity, and quality of life. Also, consider the impacts on the community of the loss of the contributions and social interactions of older adults.

3.4.4.2 **Study the Influence of Mobility Alternatives on Driving Cessation** - Evaluate the premise that the availability of satisfactory mobility alternatives actually affects the willingness of people to withdraw from driving, as described in Section 3.4.2. This analysis would be a follow on to the preliminary work ongoing with NHTSA and HHS.

3.4.4.3 **Security in Transportation** - Section 3.4.3 describes the need to ensure that the transportation system remains secure for elders, and therefore for all. A two part investigation is needed. The first part will build upon transit-related research assessing the scope of the problem. How do elders perceive transportation security as it relates to their safety and fear of victimization? How does their fear of crime relate to their willingness to leave the security of their own home, using private or public transportation services? Does the presence of the homeless in

some terminals in any way affect the use of public transit? What alternatives are available to improve the perceived and objective sense of security to encourage their use of personal vehicles or mobility alternatives?

Although technology offers many countermeasures and detection tools (e.g., Mayday alert systems), full system security requires more than hardware. The second part of the investigation will move beyond identifying solely hardware-oriented solutions and apply an integrated systems approach to the transportation/elder security issue. The results of this work will provide an inventory of the utility and appropriate uses of environmental design, security policies, procedures, transportation personnel training, and the relationship of transportation facilities to their surrounding environment to increasing the elder-friendliness and accessibility of public and private transportation services.

Two areas which should receive special emphasis are:

--Elder-Friendly Terminals - Evaluate what cost effective ways are available for increasing the user friendliness of bus, rail, and aviation terminals, the passage of the older adults into and out of the transportation systems, their protection in crashes, and their evacuation following a crash.

--Elder-Friendly Pedestrian Facilities - Evaluate ways of increasing the safety and security of pedestrian facilities to encourage the more frequent use of those facilities.

3.5 COUNTERMEASURES FOR THE FRAGILITY OF ELDERS

3.5.1 Fragility Problem Defined

As noted above, the rate of automobile fatalities associated with the elderly increases disproportionately after the age of 75. Osteoporosis and increased fragility and loss of bone and muscular strength make the elderly more vulnerable (e.g., even standard safety belts can crack ribs leading to organ punctures; similar problems can exist with airbags). With the growth of the elderly population expected over the next 25 years, in the absence of additional action by the Department to reduce their crash rate, the level of elder fatalities will become of ever greater societal concern.

The life saving benefits of air bags may be greatly diminished for adults over age 70. In purely frontal crashes, data indicate that airbags could be reducing the drivers' fatality risk by 30 percent or more for drivers up to 55 years old, but only 11 percent for drivers age 70 and older. The relative benefits may diminish further in partially frontal crashes. The data do not indicate the precise causes for this reduction in protection (See NHTSA Technical Report [27]).

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27. Fatality Reduction by Air Bags, Analysis of Accident Data through Early 1996, NHTSA Technical Report DOT HS 808 470, August 1996.

A substantial research and development program is needed to develop countermeasures to compensate for the fragility of elders. This program would involve biodynamic modeling and possibly even testing using crash dummies to gain a better understanding of the problem. Potential mitigation technologies would be considered, including improved vehicle design and smart (force limiting) belts or (smart) variable aggressivity air bags. This program would conduct research to establish age related fragility parameters and from these develop guidelines for better occupant packaging and protection of elderly from trauma both as vehicle operators and users. The experimental modeling work would build on the expertise in biodynamics developed by NHTSA as well as work done by DOD, universities, and the private sector. It should also seek to continue formal and informal public/private partnerships with researchers from the automotive industry, academic institutions and military research facilities. Some of the results of this research can be expected to be transferable to other situations where elder fragility can be a problem, such as transit buses, rail passenger trains, architectural designs for transportation terminals, and designs and procedures for emergency evacuation of aircraft.

3.5.2 Present DOT Supporting Programs

NHTSA has a strong biodynamics program aimed at the reduction of crash related injuries for all passengers. There are plans to investigate the safety of airbag deployment for children and small adults. NHTSA also is analyzing crash data to compare injuries received by older and younger motor vehicle occupants restrained by lap and shoulder belts and/or air bags.

3.5.3 Initiatives for Consideration

3.5.3.1 **Countermeasures for Fragility of Elders** - Establish a substantial research program to develop countermeasures to compensate for the fragility of older adults as described in Section 3.5.1. This research should also have transferability to other modes where the fragility of older adults can be a problem, such as transit buses and emergency evacuations (including aircraft).

3.6 TECHNOLOGICAL PROGRAMS

New technology holds great promise for developing older-friendly systems. These systems have the capacity to augment and extend the mental and physical capabilities of older transportation users and operators. There are numerous performance-aiding technologies which will become available over the next ten years to enhance the safety and ease of operating vehicles, and thus directly support older operators. Development and introduction of these new technologies in all modes is being supported by DOT and other agencies, as well as private organizations, many under the ITS program. ITS America, Inc., has become increasingly concerned about older adult issues and has established an older driver subcommittee to address the opportunities and constraints ITS presents to older operators.

Development of technological enhancements that support older adults should be driven by their identified needs rather than technological availability. There is a need to limit the tendency to

introduce complex technology for its own sake, since such complexity can also have the capacity to confuse or burden many elderly operators.

It is often the case that innovations that benefit older adults benefit other users as well. Some technologies, however, will have the capability to help individuals to compensate for specific functional impairments, only if they are designed with those particular individuals in mind. This may result in problems of higher cost and reduced availability. Further, some technologies designed for the broader public could conceivably impair the functioning of some older operators.

3.6.1 Highway Design

An increase in the time required to process new information frequently accompanies aging. As a result, older operators have greater difficulty in performing certain driving tasks, such as reading signs clustered at an intersection. Better signs and road marking allow increased braking and sight decision times. Providing the driver with additional time for such decisions increases the probability that he or she chooses the safest and most appropriate maneuver.

Although older operators may drive very cautiously, they can still encounter situations that require substantial time-critical mental processing and decision making (e.g. crossing traffic to execute a left turn on a busy street). The complexity of congested highway systems coupled with the faster moving traffic accompanying recently increased speed limits also represent serious challenges to the older driver.

In order to be ready well in advance of the coming influx of older drivers, FHWA established a high priority research program in 1989 dedicated to improving travel for an aging population. It has conducted extensive research on a host of older adult subjects, including traffic maneuver problems for older drivers, the relative visibility and information transfer characteristics of different signing designs, different forms of lane markings and delineations, the older pedestrian's ability to cross signalized intersections, and older driver freeway needs and capabilities. This research is continuing but is at the stage where much useful information is now available, and the results will soon be compiled into a *Preliminary Older Driver and Highway Safety Handbook*, for distribution to highway engineers and planners in the communities. The next efforts will include development of an implementation program to help educate the users on both what information is at their disposal and how to put the recommendations into practice for a safer, more mobile older population.

3.6.2 Vehicle Design and Ergonomics

By 2010, baby boomers will account for 57 percent of car buyers. This demographic trend emphasizes the need for continuing attention to elderly limitations in eyesight, strength, flexibility, agility, etc., in designing vehicle doors, seats, controls, and instrument panels, and understanding complicated instructions given verbally. Enhanced mirrors and ways to avoid headlamp glare problems must be sought, as well as to avoid driver information overload. This work will be a

challenge to automobile, truck, airframe and other vehicle manufacturers. Re-learning how to use the systems of each new vehicle also presents a particular problem for older adults. The efficacy of guidelines for the design of *elderly-friendly* standardized vehicle interfaces for equipment and systems needs to be assessed. However, standardization of controls and displays should not be permitted to stifle critical innovation. Where complexity is unavoidable, mitigation might be provided through short term supplemental training.

3.6.3 Simulator Development

Simulators have the potential to be supportive in many functions: for screening, as an aid for evaluation, in training older adults to use new technologies, and in research to establish test requirements or develop new driving aids. Much of the most critical research and the most important aspects of on-line operator screening are too dangerous to be conducted in traffic with real vehicles. Today's simulators have the potential to permit research and screening to be conducted safely. Continued development of advanced sophisticated simulations such as the National Advanced Driving Simulator, at the University of Iowa, will support such research, particularly work to establish test requirements or develop new driving aids. Developments of low cost simulators designed to be used in field settings have been made possible by personal computer technology. Such a low cost simulator would be especially helpful to DMVs and the health community. One particular problem with automobile simulators that incorporate motion or elaborate multiple screen displays is that a significant proportion of test subjects experience motion sickness and kinetosis. This is a particular problem for older subjects. The use of advanced driving simulators for the study of older drivers will be limited until the problem is surmounted. Any simulator must yield data that are predictive of real-world performance in safety-critical situations, and are accepted by the public as a fair and valid indicator of driving competency.

3.6.4 Fitness for Duty Testing

Many elements of DOT are sponsoring research with the goal of finding alternatives to or enhancements of hours of service regulations, and identifying the impact of debilitating factors such as illicit drugs, medications, stress, and workload. The development of practical "fitness for duty" testing device(s) is intended to address these issues. To date this technology has not been proven to be useful and development of such systems remains a challenge.

Computer based performance tests and batteries are available to assess the effects of aging, workplace stress, and work schedules on performance, but these systems have not reached a level of utility which would make them useful in an operational setting .[28]

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28. e.g., FHWA project with Truck Research Institute.

The FAA has one such tool under development, Cogscreen-AE.[29] It is a computer-administered test for use in the medical recertification evaluation of pilots with known or suspected neurological and/or psychiatric conditions. It measures the underlying perceptual, cognitive and information processing abilities associated with flying. This tool has potential for use in testing the mental capacities of all operators of all ages but can be used to identify mental changes more common to older pilots. If this tool is successful it may be adaptable for other modal applications.

3.6.5 Research on Operator Capability Requirements

There is insufficient information on the causal relationship between certain medical conditions or functional abilities and operator performance and crash involvement. We are thus limited when trying to develop clear guidelines on who should or should not drive. For instance the relative importance of strategic and tactical decisions as compared to operating skills and cognitive speed needs to be assessed.

A better understanding of the relationship of external factors to the impairments to older adults due to drug use, alcohol, and fatigue is needed. Older adults may be more affected since they have fewer resources to cope with the effects of drugs and their overall effects may be longer lasting. More research is needed to gain a better understanding of how the use of commonly prescribed medications can impair vehicle operation. Today, persons 65 and older receive 29 percent of all prescriptions. More than 80 percent take one or more medications. Information is needed on the effects of commonly used medications taken alone and in combinations. Polypharmacy is already known to be causing numerous falls and injuries among the elderly. Of particular concern are medications such as tricyclic antidepressants, benzodiazepines, and opioid analgesics. The effects of fatigue and sleep apnea are also important considerations for older commercial operators.

3.6.5.1 Performance-Based Standards - Decisions on who can operate should be performance based, but the science by which functional performance standards can be established is still lacking. For all modes, a better understanding is needed of the minimum requirements to perform driving, piloting, and way-finding tasks safely. This is very important if we are to be successful in assessing the significance of age-related cognitive, sensory, and motor declines. It has been difficult to quantify the relationships between debilitating conditions and risk of a crash. The complexity of this problem is compounded by the way the effects of impairments may be mediated by strategic and tactical decisions by the operator. Progress in these areas has varied by mode;

29. CogScreen was developed as a test of cognitive function (and not flying skills) in response to the documented observation that traditional clinical screening tests were insensitive to detection of cognitive deficit of relevance to functioning as an airman. However, the test development was intentionally structured to assess brain functioning, and not to assess flying skills per se. CogScreen is now used as a supplemental test option by neuropsychologists doing evaluations of airman on behalf of the FAA; other applications include both military and civilian entities that use CogScreen as a baseline documentation of cognitive performance on entry into an aviation job. The test is available commercially from PAR, POB 998, Odessa, FL 33556.

for example, an extensive data base exists for aviation tasks. NHTSA is sponsoring work to assign levels of severity of accident risk to medical conditions. This work is being conducted through AAAM. This work is complicated by the need to recognize and define the difference in functional level and content of tasks required by commercial and non-commercial operations.

Research into the risk of crashes from the diagnosis of debilitating medical conditions will be extremely difficult. It is likely to be complex, expensive, and long term. To be practically useful to the health care and licensing communities, it must go far beyond the current state of the art. This research will require the development of: 1) improved clinical, physical and mental assessment/screening methods; and 2) objective links between physical conditions and/or impairment, and crash risk.

3.6.6 Present DOT Supporting Programs

As noted above, research into the identification, development, introduction, and evaluation of these new technologies in all modes is being pursued by DOT's internal organizations, i.e., FHWA, NHTSA, ITS Joint Project Office, FAA, and FTA and other agencies, as well as private organizations, many under the ITS program. These are too numerous to enumerate, but the following examples offer insight into their obvious promise.

3.6.6.1 Collision Warning/Avoidance Systems - Detection of objects in the forward path of the vehicle (as well as when backing-up) has the greatest potential to save lives, not only because a substantial number of occupant collision injuries will be avoided, but because it also represents a major new countermeasure for reducing vehicle crashes involving pedestrians and bicyclists.

3.6.6.2 In-Vehicle Signing - Advance notice in the vehicle, visual or audible, of what caution, speed change, and road contour signs will shortly be encountered may afford the older driver more time to process this information and react. Included in this advance notice grouping will eventually be automatic notices of upcoming rail grade crossings, flooding, fog, and weather alerts. These systems may be even greater use to senior truck and bus operators than to private operators and will be applicable to all modes.

3.6.6.3 Security - Mayday rescue systems and collision notification systems, which automatically alert authorities of the locations of vehicles experiencing emergencies, can expedite aid to older travelers and bring some relief to their security concerns. As is true today, however, its success will depend on the location of the incident, and the response infrastructure of emergency service providers available.

3.6.6.4 Rural Public Transportation - Better use of information system technologies has the potential to improve rural transit and ride sharing services for older adults. Customer paging systems, combined with vehicle location and tracking systems, can lead to real time, more personalized and rapid service, through demand responsive (paratransit, route deviation) systems. Such systems are now being evaluated in a number of states.

3.6.7 **Initiatives for Consideration**

The various operating administrations have already launched a number of exemplary technological programs to accommodate and support the increasing number of older adults within the system. Proposed new technological applications have been limited here because so many projects are already ongoing.

3.6.7.1 **Improve our Understanding of the Relationship Between Medical Conditions, Functional Disabilities and Operator Performance** - Current information on the role of medical conditions and functional ability on crash involvement and operator performance is insufficient. Consequently we can not develop clear guidelines on who should or should not drive. Furthermore, evidence on the role of medications and safe driving is insufficient to enable physicians to prescribe the most cost effective and safe medications. The Department needs to continue supporting and conducting epidemiological research on the relationship between and among medical conditions and functional disabilities vs. crash involvement and driving practices. Current knowledge does not permit clear guidelines because risk ratios for various conditions are either contradictory, too low or not actually appraised. There is an interaction between crash involvement and driving cessation that makes it difficult to provide clear guidance to physicians or to their patients. There is also a need to determine how performance of operator tasks are related to medical conditions and functional disabilities. In addition to crash risk ratios, the actual driving behavior of individuals with functional disabilities needs to be better understood. There are those who believe that the strategic and tactical decision that an individual makes are more important than their operating skills. There is a need to conduct research into these decision processes. (See Appendix C-III for additional discussion of this issue).

3.7 IMPROVE DATA BASES TO EVALUATE THE SUCCESS OF THE PROGRAM

Strategic planning requires not only the setting of long term goals, but also establishing metrics to determine if they are being achieved. The goals here are for a positive program that invests in the elderly as users and providers of transportation services, while also improving our screening and evaluation systems to keep them safe. We need to improve the content and nature of our data bases to make better use of existing programs, to monitor the progress of continuing initiatives and to help plan new initiatives. With regard to present data bases, we must evaluate the extent to which we can meaningfully add items such as medical data, prescription drug use, travel data, residential data and (when available) the results of performance evaluations.

3.7.1 Data Base on Elderly Characteristics and Scenarios for Aging

The baby boomer cohort is predicted to have more extensive mobility needs as it ages than does the present elderly cohort. Its members currently live further from central business districts, have less access to public transit and are less likely to have been using these facilities. Furthermore, this group is composed of more two wage earning families and may in the future be able to retire

at a younger age. This last point is debatable because the increasing Social Security eligibility age, and reductions in vested retirement programs, may impact retirement patterns.

Extensive socio-demographic research is needed to get a clearer picture of the true transportation needs of this growing and important segment of the population. This can be accomplished by DOT working with the Forum for Aging Related Statistics and related gerontological statistical organizations. Another important information base would deal with characteristics of older adults as related to transportation. Ideally this data base would contain information in a consistent and accessible framework on topics such as: well elderly vs. disabled elderly; and common elderly transportation need categories. (See Appendix C-II for additional discussion of this issue).

3.7.2 Fiscal Base to Evaluate Program Effectiveness

The Department also needs to build comprehensive data bases which allow us to compare relative costs and other performance measures, in order to monitor the efficacy of our systems and policies and respond to the Government Performance Review Act. With these systems in place, we can compare public outlays that enhance elder mobility to the likely costs to society if no systematic enhancements are made. Two aspects of this fiscal data base are critical:

- Outlays for programs such as alternative mobility systems, enhanced screening and evaluation; promoting education, training and rehabilitation programs; and/or technology investments.

- Costs of elder-caused crashes (injuries, fatalities, and health care and social service costs), costs associated with non-emergency medical transportation, and medical costs associated with premature health declines due to reduced mobility.

3.7.3 Present DOT Supporting Programs

No comprehensive fiscal data bases of this sort are known, although partial data on these topics are available from sources such as HHS.

3.7.4 Initiatives for Consideration

3.7.4.1 **Long Range Transportation Needs of the Elderly** - Conduct research to evaluate what the long range transportation needs of the elderly actually will be, and to what extent they will be met with our Federally sponsored systems.

3.7.4.2 **Data Bases** - Undertake establishment of the data bases outlined immediately above.

4. IN CONCLUSION

Secretary Peña, concerned about the quality of life of the future older population, initiated this comprehensive overview of what needs can be anticipated from the changing demographic demands on the Nation's transportation system, and what improvements might be made in order to accommodate them. These demographics will find us with a large population of older adults, who are more widely dispersed, and more accustomed to a life style of full mobility. The problems highlighted above encompass the perspective of older adults as users and providers of transportation in all modes, and more than 20 possible remedial initiatives have been offered for consideration. The specific recommendations, relative priorities, and budget estimates, which would be part of a definitive long term strategic plan, are the next step.

Most of the problems discussed are part of a long term agenda. There is time to work on them before we feel the impacts of the 20 million increase in the over-65 population projected for 2020. Extensive research is needed in many areas, e.g., the need for improved understanding of exactly how older adults function and compensate for age-related differences in physiology, what the true transportation needs for older adults will be, and how they can be accommodated. New forms of mobility alternatives need to be developed and tested. Potential safety problems for certain segments of the older adult population have been noted and they will warrant continued monitoring.

Some of the problems cited, however, should be part of a shorter term agenda. The effectiveness and productivity of our testing, evaluation and rehabilitation programs need to be improved. Rapid growth in the over-80 population is already under way, and we must ask ourselves what kind of comparable growth in transportation services for them are possible. Since we cannot count on new resources, it is necessary that we get maximum efficiency out of the resources available now -- thus the emphasis on *best practices* in the mobility planning area. Further, we must develop more effective countermeasures to deal with the higher levels of fragility for this group.

The Department's leadership role in responding to the transportation needs of older adults is unquestioned and will continue. It has had effective, even exemplary, programs under way for a number of years. It is of paramount importance that these programs be well coordinated within the Department, as well as with HHS and all the other agencies that have programs for older adults at the state and community level. This extends as well to working closely with the private sector, with the various Transportation Research Board Committees, and the professional communities of other countries.

How well the Department meets the many challenges catalogued above will have far ranging impacts on the quality of life for future older adults, as well as overall safety performance for the transportation community.

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Improving Transportation

for a

Maturing Society

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Appendix A: Ongoing Research Programs [30]

I. National Highway Traffic Safety Administration (NHTSA) [31]

NHTSA continues to pursue implementation of its *Traffic Safety Plan for Older Persons* (DOT HS 807 316). The plan was originally developed in 1988 in response to the Transportation Research Board publication, *Transportation in an Aging Society*. An update completed in 1993, at the request of Congress, outlines major agency efforts to improve the safety of older drivers, vehicle occupants, and pedestrians. Current and upcoming projects are described below. NHTSA's ongoing research can be categorized as follows:

Research on Problem Identification

Establish the Crash Risk for Specified Medical/Functional Conditions. This interagency agreement with Oak Ridge National Laboratories is identifying existing databases and conducting secondary analyses to better identify older driver issues. Analyses currently underway will identify older driver problem groups requiring special attention. Anticipated completion date is 1997. Principal Investigator: Pat Hu, Oak Ridge National Laboratories (423) 574-5284.

A Model System to Improve Self and Institutional Regulation of Driving by Older People. Older driver groups who need assistance determining when to stop or alter their driving are being identified, along with support resources in the social service and aging network who come into contact with them and can provide needed assistance. Guidelines for detecting limitations and for providing help in driving decisions are being developed. Anticipated completion date: 1997. Principal Investigator: R.O.W. Sciences, Inc. (301) 294-5471.

Analyze Vehicle Crash Worthiness for Older Occupants. NHTSA is analyzing crash data to compare injuries received by older and younger motor vehicle occupants restrained by lap and shoulder belts and/or air bags. Since older persons are more likely to be involved in side-impact crashes, changes in injury patterns are being monitored over the next few years as the new side-impact regulation, requiring manufacturers to install side padding and structural improvements, is phased in. Anticipated completion date: Ongoing. Contact: Cathy McCullough, NHTSA (202) 366-4734.

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1. Many of the following project descriptions are drawn from the July 1996 Newsletter of the Committee on the Safe Mobility of Older Persons, A3B13, Transportation Research Board, National Research Council, 2101 Constitution Ave., NW, Washington, DC 20418.

2. National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation, 400 7th Street, SW, Washington, DC 20590, Contact: John Eberhard (202) 366-5595.

Intersection Negotiation Problems of Older Drivers. The causes of older driver problems at intersections, especially those involving left turns, are being investigated. Findings will be used to develop new information and training materials for older drivers. Anticipated completion date: 1997. Principal Investigator: Loren Staplin, Scientex Corp. (215) 412-4912.

Family and Friends Reporting and Assisting Problem Older Drivers. Guidelines and program materials are being developed to facilitate involvement by family and friends in the driving decisions of problem older drivers. Focus groups are underway to explore how family and friends help high-risk older drivers and how to overcome barriers to their involvement. An in-depth survey of eight state licensing agencies is being initiated to examine actual experiences with family, friends and others reporting potentially unsafe older drivers to state authorities. Surveys have been conducted with professionals involved with or concerned about older driver safety to determine information and resource needs. Anticipated completion date: December 1996. Principal Investigators: Ronni and Harvey Sterns, LIFESPAN Associates Inc. (330) 867-6336.

Older Driver Family Assistance. The 402 project will identify and develop strategies to help families assist older persons with driving difficulties. Barriers to family involvement and the role of safety and other professionals in supporting concerned family members are being determined. A handbook will be developed of recommended strategies to assist families. Results will be incorporated into a preexisting care giver assistance program in New York. Anticipated completion date: 1997. Project Leader: Philip LePore, New York State Department of Aging (518) 486-2727.

Identify Specific Vehicle Design Practices that Enhance Older Driver Crash Avoidance. NHTSA is examining vehicle design practices and advanced-technology crash-avoidance countermeasures to determine which have the greatest safety potential for older drivers. Specific practices and countermeasures will be recommended. (As a standard practice, NHTSA considers the needs and functional limitations of older drivers in virtually all of its crash avoidance research.) Anticipated completion date: Ongoing. Contact: Michael Perel, NHTSA (202) 366-5675.

Program Development

Update National Medical Standards and Examiner Training Programs. Findings and conclusions of current research and literature will be used to refine existing and develop new medical standards for physicians and other practitioners to use in identifying high-risk problem drivers. State licensing agencies will be provided with an updated guidebook, "Functional Aspects of Driver Impairment - A Guide for State Medical Advisory Boards," which includes recommended medical standards for making licensing decisions. Support is also being provided to the AAMVA for updating information on older drivers contained in training materials developed for driver license examiners. Anticipated completion date: 1997. Principal Investigator: Elaine Petrucelli, Association for the Advancement of Automotive Medicine (847) 390-8927.

Develop Performance Assessment Techniques. Under a cooperative agreement with the California Department of Motor Vehicles, tests are being selected and designed to evaluate the status of drivers with dementia or age-related frailties. Anticipated completion date: Summer 1997. Principal Investigator: Mary Janke, California DMV (916) 657-7032.

Health Community Involvement with Problem Older Drivers. Health care disciplines that have contact with problem older drivers will be identified, and ways will be assessed in which they can be more involved in advising their patients/clients about driving modifications and reporting them, as needed, to appropriate state authorities. A "how to" kit will be developed for health care providers working with older drivers and families on needed driving adjustments. Anticipated start date: April 1997.

Model Driver Screening and Evaluation Program. Recently created screening and assessment procedures will be identified, evaluated and classified by purpose and target conditions. The degree to which the procedures are suitable for (or adaptable to) making recommendations about driving decisions and licensing actions will be determined. Testing procedures will be modified or developed, as needed, and pilot tested. Anticipated completion date: Spring, 1996. Principle Investigator, Loren Staplin, (215) 412-4912

Validate Statistical Models Relating Functional Limitations to Driving Cessation and Crash Involvement. Models of driving cessation and crash involvement developed by Oak Ridge National Laboratories with the Iowa EPEE data will be validated with additional data bases for another location (Salisbury, MD). Anticipated completion date: Summer 1997, Johns Hopkins University, Gary Rubin, (410) 550-6429

Improve Safe Mobility of Older Persons. Funded by NHTSA and the Federal Highway Administration, this study will establish requirements for identifying, developing, demonstrating and implementing measures that would allow older persons to safely extend their driving years. Research thrusts address: improved driving skills, driver assessment, cognitive retraining, technology-based cognitive aids, enhanced the assisting nature of transportation, and use of emerging technology as a potential surrogate for certain types of travel. Anticipated completion date: Summer 1997. Ed Crow (814) 863-9887

II. Federal Highway Administration (FHWA)[32]

Improved Highway Travel for an Aging Population. In 1989 a High Priority Area was initiated by the Federal Highway Administration's Human Factors Safety Research Program to address problems faced by older road users. The urgency of the program was spurred by the nation's population increase in people over age 65, especially the estimated projection that this segment of the population will total more than 65 million people by the year 2030. In addition, research shows older drivers are over-represented in traffic fatalities. Although older drivers drive fewer miles than younger drivers (age 35 and under), their fatality rate is much higher. Age

3. Federal Highway Administration (FHWA), U.S. Department of Transportation, 6300 Georgetown Pike, McLean, VA 22101, Contact: Truman Mast (703) 285-2404.

related changes in cognitive functioning, perception, and psychomotor limitations are issues currently addressed in studies examining countermeasures under this High Priority Area. The studies being conducted will identify, develop, and evaluate a variety of engineering enhancements to the highway system to meet the needs of older road users.

Results of many of the studies include recommendations for practical and implementable changes that will help improve performance of all drivers, including those over 65. It is expected that improvements resulting from this program can be implemented before the United States population's average age increases significantly. A discussion of the completed and the current studies follows:

Traffic Maneuver Problems of Older Drivers. Since little was known about the specific changes in driving abilities as people age, this study was conducted to examine the limitations and capabilities of older drivers to perform important driving maneuvers required for driving on modem roadways. The feasibility of employing non-interactive videodisc (or other) technology for testing the laboratory performance of drivers with diminished capacity was also investigated. This study identified the most critical limitations and capabilities of older drivers. Analyses support the hypothesis that older drivers are over- represented in accidents as a result of turning and merging maneuvers.

It was also found that older drivers do not overestimate the time-to-collision for vehicles approaching either head-on or on an intersecting path, leading to consideration for other hypotheses for older drivers' involvement in these types of accidents. In addition, the study found that subjects' responses to laboratory stimuli using 35 mm film were comparable to field data responses, indicating the utility of this medium. Guidelines for design changes for highway design and traffic control devices were recommended to enhance older drivers' mobility. One example of a recommended guideline included implementing highway elements at intersections to identify conflict vehicles that are approaching at high speed. The study has been completed and has been published by FHWA (Publication No. FHWA-RD-92-092).

Older Driver Perception Reaction Time for Intersection Sight Distance and Object Detection. Current American Association of State Highway and Transportation Officials (AASHTO) values for sight distance were hypothesized as not fully addressing increased reaction times which may be a part of age-related changes. This study investigated intersection sight distance, stopping sight distance, decision sight distance, and gap/lag acceptance by older drivers in order to assess the appropriateness of current perception reaction time values used in design equations. In doing this, the researchers also assessed the utility and feasibility of alternate gap acceptance models for highway and intersection design. Findings obtained from all drivers (young, middle-age, and old) supported the appropriateness of the current AASHTO design standards of 2.5 seconds for stopping sight distance and 2. 0 seconds for stop controlled intersection sight distance. Decision sight distance values, 10.0 seconds for freeways and 1.2 seconds for arterials, were also found to be adequate. (Publication No. FHWA-RD-93 -168).

Relative Visibility of Increased Legend Size Versus Brighter Materials. Technology in retro-reflective sheeting materials has improved greatly through recent years. This study was designed to examine the needs of older drivers in terms of recognition distance and legibility of

signs with different color backgrounds, different stroke widths of lettering, and different Manual of Uniform Traffic Control Devices fonts. This study examined older and younger drivers' responses to brighter signs versus larger signs and evaluated other characteristics related to lettering (font, spacing, capitalization) under day and night viewing conditions.

Major findings showed that tested sign materials did not have an effect on dynamic legibility and construction signs (black lettering on orange) were found to have greater conspicuity values than regulatory (black on white) signs. Furthermore, increases in letter height beyond sixteen inches did not produce significant, additive changes in legibility distance.

Based on the results of the study, engineering guidelines with recommendations for sheeting material use were produced, as were recommendations regarding font type and letter spacing to enhance older drivers' abilities to see and read signs from a greater distance. Economic analysis of sign size versus retro-reflective materials was another important product of this study. (Publication No. FHWA-RD-94-035)

Pavement Markings and Delineation for Older Drivers. Older drivers may need enhanced pavement markings and delineations in order to remain safely within their lanes and focus on downstream geometry. This study identified and evaluated situations in which older driver performance may be improved by enhanced delineation and pavement markings. It also determined the effect of enhanced delineation and pavement markings on driver behavior, particularly older drivers. Findings showed that combinations of treatments which included two elements (both edge line delineation and off-road elements) were more effective than any single treatment for all age groups. This effect was also more pronounced for the older drivers.

The chief product of this study is the identification of the delineation needs of older drivers. Findings show that combinations of treatments that include two elements (both edge line delineation and off-road elements) are more effective than any single treatment for all age groups, but especially for older drivers. Changes to current delineation and pavement marking treatments based on study findings were also recommended, along with changes to engineering guidelines for enhanced delineation systems. (Publication No. FHWA-RD-94-145). Anticipated completion date: Summer 1996. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Symbol Signing Design for Older Drivers. Many symbol signs currently in use are either confusing, or ambiguous, especially for older drivers. A number of symbol signs have demonstrated low comprehension due to their complex design, low conspicuity, and unrecognizableness. This study was conducted to identify problematic signs, test alternatives, and investigate individual elements of symbol signs to assess their criticality for good sign design. One major product also included the development of symbol sign design guidelines.

Results of this study showed that, on every sign tested, mean visibility distances were lower for elderly drivers than either young or middle-aged drivers. Reaction time (for sign recognition) was greatest for the older drivers and lowest for younger drivers. A process to improve signs used a Fourier analysis technique that helped to define critical elements for symbol signs. Based on this technique, a set of redesigned and modified signs was developed and assessed. Findings for these signs showed that drivers understood these signs significantly better than the original signs and the

recognition distances increased. Based on these finding, guidelines for symbol sign design have been developed. Results are currently in publication (Publication No. FHWA-RD-94-069).

Traffic Operations Control for Older Drivers. Older persons, as drivers or pedestrians, appear to have disproportionate rates of involvement in accidents at intersections and other situations. This study was conducted to define the safety problems of older drivers and pedestrians. Alternative designs for use in rural and urban settings were evaluated to help accommodate the perceptual, cognitive, and psychomotor capabilities of older drivers and pedestrians and make recommendations regarding changes to current standards. Intersection features examined included traffic signal display type, signal placement and phasing, off-peak and on-peak operations, day and night operations, left turn arrows, intersection geometry, and intersection visual complexity.

Findings showed that one countermeasure developed, a pedestrian signal education placard, did not change pedestrian behavior at intersections. In addition, results showed there is a general misunderstanding of the protected phase of left-turn, protected/permitted signals. Older drivers tend to believe the permitted phase gives them the right-of-way. Recommended changes to current intersection traffic control device standards to accommodate older drivers and pedestrians will be the primary product of this research. (Publication No. FHWA-RD-94-119). Anticipated completion date: Summer 1996. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Older Pedestrian Characteristics for Use in Highway Design. Information gaps currently exist on the mental and physical functions essential for the pedestrian movement of older persons. This is especially apparent at signalized intersections where older pedestrians have a great deal of difficulty crossing before the signal changes due to age-related changes in perception, response time, and motor abilities. This study assessed the current capabilities of older pedestrians through a task analysis, information gathered from older pedestrians through surveys and focus groups, and field observation studies.

Major findings show that, when compared to younger pedestrians, older pedestrians displayed: (1) crossing start-up times that were approximately *25* percent greater; (2) walking speed that is significantly slower; and (3) stride lengths that were about 86 percent of younger pedestrians. Therefore, the observed slower walking speeds of the older pedestrians may be due to their shorter stride lengths. (Publication No. FHWA-RD-93-177).

Assessment of the Capabilities of the Iowa Driving Simulator. The development of the Iowa Driving Simulator (IDS) has the potential to enhance the FHWA's research capabilities. To ensure the IDS can help in FHWA's human factors research program, this study was conducted to assess the IDS's capabilities on several performance dimensions and provide performance data to the FHWA for further analysis. The results of this study showed that older drivers drove slower, made significantly more accelerator pedal reversals on the highway on-ramp than younger drivers, and had less variance in lane placement in the straight segment when compared to young drivers. The inclusion of intersection turning maneuvers in the driving scenario was found to be a significant factor leading to simulator sickness; and self-reported measures proved reliable indicators of possible sickness onset. In addition, obtained ratings from test subjects showed the IDS is perceived as having a high degree of realism and fidelity.

Investigation of Older Driver Freeway Needs and Capabilities. Freeways are an integral part of an individual's mobility in the United States, yet it is not known if the required capabilities for using them exceed older drivers' actual capabilities. This study identified characteristics of drivers 65 years and older that affect their needs and capabilities with regard to freeway driving. This study also assessed the freeway driving environment elements which are problematic for drivers 65 and older.

The product of this problem identification research was a delineation of the problems which confront the older driver on freeways. Future research to develop guidelines for countermeasures to address problems to accommodate drivers 65 and over will be recommended. Anticipated completion date: Summer 1996. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Delineation of Hazards for Older Drivers. Object markers are used to delineate obstructions within or adjacent to the roadway. Over the years the exact meaning of these markers has become unclear. Experts disagree on whether the markers should convey the presence of an object or a sense of a hazard to the driver. There is also confusion between the use of object markers and standard delineation and marking treatments.

This study will achieve four objectives: (1) identify conspicuity, recognizability, and comprehensibility problems with object markers, particularly as they relate to the needs and capabilities of the older driver; (2) determine, through empirical research, the effect of enhancements in the design and implementation of object markers, including an analysis of the impact of these changes on the comprehension of other devices; (3) perform cost/benefit analyses associated with changes in the design and implementation of object markers; and (4) make recommendations regarding changes to the current design and implementation of object markers and discuss potential effects of such changes on safety and traffic operations.

Preliminary results show that subjects correctly comprehended only 36 percent of object markers presented and older drivers produced significantly more incorrect responses when compared to younger drivers. In general, findings also showed that hazard markers seemed to have little effect on subjects' perception of hazards -they had the greatest effect on those objects that are already conspicuous, such as trees, poles, and bridge abutments. Finally, the Type 3 markers (vertical, striped) were shown to be more effective than both Type 1 (yellow diamond) and Type 2 (small yellow rectangle).

Products that will be developed from this study include: (1) the identification of recognition, conspicuity, and comprehension difficulties of object markers for older drivers; (2) cost/benefit analysis of design changes to object markers; and (3) recommendations for object marker design changes. Anticipated completion date: Winter 1996. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Intersection Geometric Design for Older Drivers and Pedestrians. Older drivers' and pedestrians' abilities to safely maneuver through intersections is of great concern due to the high proportion of accidents and fatalities occurring at intersections in the older population. This contract will identify this population's capabilities that most significantly reflect their needs and impact their abilities at intersections. Results will be used to identify geometric and operational

(e..g., one-way designations, signal timing, etc.) aspects of intersections that can be modified to better serve older drivers and older pedestrians.

Products of the project include guidelines for intersection geometric design and operations that accommodate the needs and capabilities of older drivers and older pedestrians. Results will also be used to identify those situations where geometric design and operational changes would intersections or are not feasible or would not ameliorate problems for older road users at intersections. Anticipated completion date: Fall 1996. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Integration of Older Drivers and Highway Safety Research. The improved highway travel for an aging population research area is a comprehensive and integrated human factors study effort. Due to the number of studies in this area, there is a need to make the results of these studies accessible to end users. These end users are identified as the designers and engineers who will implement changes to current practices for overall improvements to operational efficiency, highway safety, and driver mobility. In order for the research findings to be useful to the highway safety community, the findings must first be synthesized.

Under this contract, all results obtained in the FHWA High Priority Area titled, "Improved Highway Travel for an Aging Population" and data and information from other sources will be reviewed. From this, a state-of-the-art synthesis describing the relationships between older driver needs and capabilities and highway issues will be developed. These findings will be extracted and incorporated into handbook format that can easily be used by engineers. This research will also identify gaps in knowledge. Another product of this study will be recommendations for a comprehensive research program for FHWA to implement over the next five to seven years. Anticipated completion date: Spring 1997. Contact: Joseph Moyer, FHWA (703) 285-2008.

Computer Aided Technique for Optimizing Symbol Signs. This study will provide for the development of a system using the recursive blurring technique as an aid for developing, modifying, and improving symbol signs. This computer-based system will be developed for use by highway sign designers to provide a more efficient and cost-effective means to ensure high levels of conspicuity, recognizability, and comprehension can be achieved by drivers. Anticipated completion date: Spring 1997. Contact: Elizabeth Alicandri, FHWA (703) 285-2415.

Human Factors Research Program for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)

The FHWA human factors ATIS/CVO research area examines a variety of human factors issues such as the information requirements of commercial and private vehicle drivers, display formats, information reliability, and CVO driver fatigue. Technology and methods for providing drivers the needed information in a safe and effective manner are studied employing a human-centered approach. The driver’s needs and requirements, rather than available or projected technology will drive the research for in-vehicle systems.

Mobility at the Public Service Level. It has been determined that many of the emerging Intelligent Transportation Society (ITS) systems will present opportunities for increased mobility and safety for older operators. Concurrently these same systems can also potentially present safety hazards to transportation. To address older operator and ITS issues, the ITS of America's Safety and Human Factors (S&HF) Committee, currently Chaired by Eugene I. Faber of the Ford Motor Company, has recently initiated a new S&HF Subcommittee on Older Drivers and ITS. This Older Driver Subcommittee will be chaired by Allan Tull, Board Member of the American Association of Retired Persons (AARP). This subcommittee will discuss safety and human factors issues and opportunities presented by ITS. As a member of the S&HF Committee, the FHWA has agreed to actively support this new subcommittee. This will be in addition to FHWA's current support of TRB Committee A3 B13, Older Driver Safety and Mobility Committee.

These research issues are investigated within the context of a wide range of services to be provided under ATIS. These include such services as routing and navigation, motorist services, and safety advisories and warning systems. These subsystems will be investigated as separate components as well as part of a fully integrated ATIS. For example, motorists must currently depend on external roadway signing for routing, warning, regulatory and advisory information. The signs are expensive to maintain and often cannot be read, especially by older drivers, at night, or in rain, snow, or under similar degraded conditions. A major portion of external signing information can potentially be presented on displays inside the vehicle. However, studies are needed to assess the needs of drivers in terms of what signing may be displayed, and how it should be displayed inside the vehicle.

III. Federal Transit Administration(FTA)[33]

FTA continues to pursue implementation of its age-related programs. Current and upcoming projects are described below. FTA's on-going research can be categorized as follows:

Deployment of the Independent Transportation Network. Building on the results of previous research and experience with the Independent Transportation Network (ITN), this two-year project is intended to bring the ITN to the point of financial independence and explore the feasibility of using intelligent transportation system applications such as smart cards and geographic information systems to predict future markets. Anticipated completion date: 1998; Project Director: Katherine Freund (207) 828-8608.

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4. Federal Transit Administration (FTA), U.S. Department of Transportation, 400 7th Street, SW, Washington, DC 20590, Contact: Stewart McKeown (202) 366-0244.

IV. DOT/DHHS Coordinating Council on Human Service Transportation[34]

Mobility Consequences of Relinquishing the Driver License. The mobility consequences expressed by older persons who reduce or stop driving will be documented. Anticipated completion date: Winter 1996. Principal Investigator: Jon Burkhardt, Ecosometrics (301) 652-2414.

V. University Transportation Centers Program (UTCP)[35]

Enhancing Information Transfer for the Older Driver. Results of research in sensory and cognitive performance of older drivers over the past decade will be synthesized and summarized in a design guide for use by municipal and state traffic engineers. Anticipated completion date: October 1996. Principal Investigator: Rodger Koppa, Texas A&M University (409) 845-3540.

VI. National Institute on Aging (NIA)[36]

Current NIA projects are as follows:

Evaluation of a Medical Intervention to Reduce Crash Involvement and Injuries in Older Drivers. The effects of cataract surgery on driving habits, mobility and crash risk are examined for a sample of older adults. Changes in vision, cognition, general and psychological health, driving habits and activities of daily living are evaluated. Principal Investigator: Cynthia Owsley, University of Alabama at Birmingham (205) 325-8635.

Evaluation of a Behavioral Intervention to Reduce Crash Involvement and Injuries in Older Drivers. A behavioral testing and retraining program are being examined to improve visual attention deficits previously shown to be predictive of crash frequency in older drivers. The project has two primary objectives: (1) *Evaluate the Useful Field of View (UFOV) as a functional test of driving competence.* The UFOV is being evaluated prospectively in the field to determine its effectiveness as a predictor of driving performance on the road, simulated driving performance, future vehicle collisions, and continued mobility. Data on UFOV reductions are being obtained simultaneously with indices of visual function, mental status and cognitive function to evaluate batteries of predictors. (2) *Evaluate the UFOV as a behavioral intervention to improve functional skills necessary for driving competence.* The UFOV is being evaluated prospectively at multiple sites with varying populations to determine whether it can be used to

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5. DOT/DHHS Coordinating Council on Human Service Transportation, Office of Intergovernmental Affairs, Hubert Humphrey Building, 200 Independence Avenue, SW, Washington, DC 20201, Contact: Dianne McSwain (202) 401-5926.

6. University Transportation Centers Program (UTCP), U.S. Department of Transportation, 400 7th St., SW, Washington, DC 20590, Contact Elaine Joost (202) 366-5442.

7. National Institute on Aging (NIA), 7201 Wisconsin Avenue, Bethesda, MD 20892, Contact: Jared B. Jobe (301) 496-3137.

prolong driving and reduce collisions among older drivers. Principal Investigator: Karlene Ball, University of Alabama at Birmingham (205) 975-2290.

Objective 1 Evaluation of the UFOV As a Functional Test

This objective is being pursued through collaborative activities as follows:

Salisbury Eye Evaluation Study. This is a large sample epidemiological study which examines the association between specific components of visual loss, including UFOV, and specific types of functional disability. The second wave of data collection is currently underway. To date, results show that each of the vision tests (acuity, contrast sensitivity, disability glare, stereo acuity, visual fields and UFOV loss) are significantly associated with perceived difficulty in driving after adjusting for age, race, gender and education. Multiple regression analyses reveal significant independent contributions of acuity, contrast sensitivity, stereo acuity and visual fields. The findings are consistent with previous results indicating that individuals with reduced attentional function are less aware of their impairments than those with vision losses. Project Leader: Gary Rubin, John Hopkins University (410) 550-6429.

Alzheimer's Disease and Driving Performance. The UFOV is being evaluated as part of a larger study on the effects of Alzheimer's Disease (AD) on driving performance. Participants are in varying stages of the disease and have had in clinic and on-road assessments. Data collection has been completed. Results reported at a recent conference (Alzheimer's Disease and Driving, May 17-18, 1996 at Washington University, St. Louis) indicate that the UFOV is strongly related to passing an on-the-road driving evaluation, and that attentional measures like the UFOV are better predictors of driving performance in mild AD than the diagnosis itself. Project Leader: Linda Hunt, Washington University, St. Louis (314) 362-6911.

Alzheimer's Disease and Driving Performance. The UFOV is being evaluated as part of a larger study investigating the effects of Alzheimer's Disease and driving performance. The primary goal of the project is to develop fair and accurate criteria for determining whether older individuals, and especially those with AD, remain fit drivers. The effects of UFOV reduction on driving performance in the IDS are examined. UFOV loss correlated with an increased number of crashes in the IDS, resembling the relationship of UFOV loss to state reported crashes reported earlier in the literature. The AD drivers showed significantly greater reduction in the UFOV and significantly more crash involvement than an age-matched control group. Project Leader: Matthew Rizzo, University of Iowa (319) 356-8755.

Prospective Driving Study. This project involves a prospective evaluation of risk factors for crash involvement among a community dwelling sample of older drivers. To date, results show that only 26 percent of drivers identified as high risk remain crash free for a period of three years, while 97 percent of low risk drivers remain crash free. Project Leaders: Karlene Ball (205) 975-2290 and Cynthia Owsley (205) 325-8635.

Objective 2-Evaluation of the UFOV as a Behavioral Intervention

This objective is being pursued with different study populations and through collaborative activities as follows:

Subjects Referred for Driving Evaluation. This study involves a population referred by physicians to a driving evaluation program. Project Leaders: Karlene Ball (205) 975-2290 and Thomas Kadina, Bryn Mar. Rehabilitation (610) 251-5688.

Referrals from Insurance Records. This study involves a population recruited through insurance records. Project Leaders: Karlene Ball (205) 975-2290 and Christie Branch, Rehabilitation Institute of Chicago (312) 908-6277.

Volunteers from SBIR Project. This population consists of volunteers recruited through an SBIR Phase II project. During the first two years of the study, 456 older drivers were screened for attentional difficulties (UFOV reduction) and those with a restriction were recruited for a training study. Some participants received UFOV training, some received driver simulator training and others served as age-matched controls. In the first follow-up, the UFOV training was shown to transfer to improved stopping time in a driving simulator and had a significant reduction in hazardous driving maneuvers during an on-road driving evaluation (relative to the simulator and control group performance). At the 18-month follow-up, the training benefits had waned, but performance was still significantly better than pre-training levels. Anticipated completion date: August 1996. Project Leader: Daniel Roenker, Visual Resources, Inc.

Community-Based Volunteers. This population consists primarily of volunteers recruited from the community. Project Leader: Linda Hunt, Washington University, St. Louis (314) 362-6911.

VIII. Centers for Disease Control and Prevention[37]

Health Status and Driving. The relationship between health status and driving is examined with data collected from an annual mail survey and from personal visits with residents in a California retirement community. Health indicators examined include medical condition, functional ability and use of medications. Indicators of driving patterns include crash frequency and driving limitation or cessation. Main reasons why older adults limit or stop driving and health measures that best predict driving status and ability are identified. Anticipated completion date: June 1996. Principal Investigator: Ann Dellinger, Centers for Disease Control and Prevention (770) 488-4811.

Health Status and Crash Risk. The 1995 Florida Behavioral Risk Factors Surveillance System, a statewide sample telephone survey, requested information on driving patterns from respondents aged 55 and above. These data will be combined with a database from California to more extensively examine the relation between medical conditions and crash risk. Comparability of the

8. Centers for Disease Control and Prevention, 4770 Buford Highway NE, Atlanta, GA 30341, Contact: Julie Russell (404) 488-4652.

California cohort and the Florida sample will be established, and key characteristics associated with crash involvement will be identified, e.g., demographics, health status and medical conditions, safety belt use, alcohol use, miles driven. Anticipated completion date: October 1996. Principal Investigator: Ann Dellinger, Centers for Disease Control and Prevention (770) 488-4811.

Driver Capabilities and Vehicle Operation. The effect of driver capabilities on the safe operation of motor vehicles is examined. Psychophysical capabilities are assessed through a battery of tests designed specifically to tap capabilities shown to relate to age and highway crashes. Results are expected to help improve methods for detecting drivers with abilities that may be diminished by age and provide guidance in the formulation of licensing actions that optimally balance safety and mobility needs. Project findings also will have application in the development of valid tests to assess driving ability and driving safety. Anticipated completion date: Fall 1997. Principal Investigator: Jim McKnight, National Public Services Research Institute (301) 731-9891.

Benzodiazepine Use and Older Driver Crashes. The effects of benzodiazepines on crash involvement of older drivers are being assessed as part of a surveillance system being created to permit epidemiological studies examining the influences of prescribed medications on crash risk. The surveillance system could also have application for research on the efficacy of interventions to reduce high-risk medication use. Principal Investigator: Wayne Ray, Vanderbilt University (615) 322-2017.

Dementia and Driving Performance. The relations between driving ability, crashes, age and dementia are being examined. The performance of adults with Alzheimer's Disease is being evaluated on a driving simulator and on a battery of off-road behavioral tests and compared with actual road-test scores and state driving records. Neuropsychological and psychophysical measures that best discriminate between safe and unsafe drivers are identified. Results will be used to develop fair and accurate criteria for predicting driving ability in cognitively impaired populations. Principal Investigator: Matthew Rizzo, University of Iowa (319) 356-8755.

Longitudinal Analysis of High Risk Older Drivers. Data collected as part of an earlier study of the effectiveness of Medicare-reimbursed screening and health promotion services are being linked to North Carolina driver history data to explore the impact of medical conditions on driving safety. Anticipated completion date: Fall 1996. Principal Investigator: Jane Stutts, University of North Carolina (919) 962-2202.

Prospective Cohort Analysis of Health Status and Driving Risk. A prospective cohort analysis is underway to assess the usefulness of certain brief cognitive and visual screening assessments for identifying older drivers at increased risk of crash involvement. Data were collected from 3,200 drivers aged 65 and above applying for renewal of their North Carolina driver's license from July 1994 through December 1995. Preliminary analyses show that the timed road sign recognition test and Trails B performance are the measures most strongly correlated with recent crash involvement. Later analyses will examine the association of the various cognitive and visual function measures with future crash involvement. Anticipated

completion date: Fall 1996. Principal Investigator: Jane Stutts, University of North Carolina (919) 962-2202.

VIII. National Institute on Alcohol Abuse and Alcoholism[38]

Alcohol, Aging and Driving Performance. The interrelationships among aging, gender, alcohol use and driving performance are being investigated. The effects on driving performance of low levels of blood alcohol in combination with age, gender, driving complexity and sleep deprivation are being studied. In a secondary task, a modified Stroop test examines how alcohol may affect the performance of older drivers in intelligent transportation systems. Findings should be useful in counseling older persons regarding driving and alcohol use. Anticipated completion date: November 1998. Principal Investigator: Patricia F. Waller, University of Michigan (313) 764-6505.

IX. Selected Other Research Programs

Andrus Foundation
601 E Street NW
Washington, DC 20049
Contact: John Feather (202) 434-6200

The Andrus Foundation has a strategic planning process underway that will define new initiatives. Projects currently underway are described below.

Identify At-Risk Older Drivers. A screening instrument method for identifying at-risk older drivers is being developed. Previous work on cognition, vision and psychomotor function has been reviewed and is being incorporated as appropriate into the screening device. Anticipated completion date: Summer 1996. Principal Investigator: Rich Marottoli, Yale University (203) 785-3344.

Physician Assessment Tools. Simple tools are being identified for use in a physician's office to assess driving skills of older, functionally impaired individuals. Anticipated completion date: Summer 1996. Principal Investigators: Penny Keyl (410) 955-3479 and George Rebok, John Hopkins University.

The Safe Older Driver: Sensory and Medical Characteristics. A cross-sectional epidemiological study is being conducted to examine sensory and medical factors associated with safe and unsafe driving behavior among a random sample of community dwelling adults aged 55 plus in Marin County, California. Factors predicting subsequent safe driving are being defined and specific problem areas in mental and physical functioning as they relate to driving are being identified.

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9. National Institute on Alcohol Abuse and Alcoholism, The Wilico Building, 6000 Executive Blvd, Bethesda, MD 20892, Contact: James Vaughan (301) 443-4375.

Preliminary data show that drivers who report that they self-restrict their driving vary from 40 percent of respondents aged 55-64 to as many as 73 percent of those 85 years plus. Almost one-third of all current drivers report they restrict their driving due to vision problems. Rarely are driving restrictions self-imposed due to problems with hearing, arthritis, balance and shortness of breath. It is expected that the sensory and medical characteristics found to be significant in this study can be quantified as part of a standard licensing protocol for older drivers. The results will also have application for the development of screening and training programs, graded licenses and street lighting and traffic signage standards. Anticipated completion date: Summer 1996. Principal Investigator: Catherine West, Buck Center for Research in Aging (415) 899-1800.

Predictors of Safe and Unsafe Driving in the Elderly. Visual, physical and mental function measures are identified that predict safe driving and adverse driving events when assessed over time. Using a prospective research design, this study will infer cause and effect and clarify the risk associated with sensory and medical characteristics. Data from an existing sample of older residents in Marin County, California, drawn in 1989, and a separate database that is currently being collected will be analyzed. Results are expected to be useful in developing improved clinical driver evaluations and standard licensing protocols for older drivers. Anticipated completion date: July 1997. Principal Investigator: Catherine West, Buck Center for Research in Aging (415) 899-1800.

Role of Cognitive Style in Driving. The role of cognitive style in the driving skills of young, middle-aged and older adults are examined. Relationships are assessed between field dependence-independence (cognitive style), specific driving skills (sensitivity to bodily cues under skid conditions, overcoming embeddedness in the perception of road signs and in the recognition of developing hazards, defensive driving in high speed traffic) and more general cognitive processes relevant to driving (e.g., reaction time, selective attention). Age differences are examined in how cognitive style functioning and driving skill relate over the course of adult development. The feasibility of obtaining predictive measures of driving performance by the use of computer-aided testing technology is explored. The findings have implications for the most efficacious means of assessing driving behavior (self-reporting vs. computer programs vs. actual road testing) and the design of training research and programs for improving older driver skills. Anticipated completion date: January 1997. Principal Investigators: Jack Demick (617) 573-829 and Debra Harkins, Suffolk University.

AARP
601 E. Street NW
Washington, DC 20049
Contact: Katie Sloan (202) 434-6057

Alternative Transportation for Seniors: A Positive Option for Families and Policy Makers. Jointly funded by AARP, FTA and NHTSA, this five-month project explores the relation between the availability of alternative transportation and driving cessation. Two specific questions are addressed: (1) Does the existence of a private automobile-based transportation alternative impact the decision of older drivers to stop driving?; and (2) Do older adults who rely on family and friends for transportation feel they have adequate mobility? Data are obtained from 90 structured,

face-to-face interviews with older drivers, former drivers and never drivers. Principal Investigator: Katherine Freund (207) 828-8608.

AAA Foundation for Traffic Safety
1440 New York Avenue NW
Suite 201
Washington, DC 20005
Contact: Dave Willis (202) 638-5344

Older Driver Video. Production is underway on a video that encourages safe driving performance among older drivers and emphasizes the need to adjust driving patterns to current capabilities. Special attention is drawn to the interaction of alcohol and other drugs, and their effects on alertness. The video will provide an informative and up-to-date resource for use in driver improvement and refresher programs. Completed: Winter 1996, now available.

Public Service Announcements. A set of 30 second television PSAs are being developed to promote older driver safety. The messages are being excerpted from the older driver video that is currently in production. The PSAs will be distributed throughout North America. Anticipated completion date: Winter 1996.

Alzheimer's Association of America
919 North Michigan Avenue
Suite 1000
Chicago, IL 60611
Contact: Catherine M. Ekstrom (312) 335-8700

Impact of Driving Cessation on Adults with Alzheimer's and Care Givers. This pilot project assesses the psychosocial impact of driving cessation on older adults with Alzheimer's and other dementias and their care givers. Using motor vehicle records and community resources to identify research participants, focus group and survey data are being collected to examine behavioral antecedents and social and affective consequences of driving cessation. The use of transportation services and the role and impact of family, friends and others in driving and running errands for the "care recipient" are examined. Findings will be used to design a larger scale study and will suggest direction for needed transportation-related policies. Anticipated completion date: March 1997. Principal Investigator: David Reuben, University of California, Los Angeles (310) 825-8253.

California Department of Motor Vehicles
2415 1st Avenue
Sacramento, CA 95818
Contact: Ray Peck (916) 657-7031

Effects of Driving Restrictions and Driving Cessation on the Older Adult. This project examines the effects of driving restrictions as an alternative to license revocation when continued but limited driving is appropriate, and the impact that driving cessation has on the self-esteem of

older adults. Also assessed is how family and friends are affected by the driving cessation of their older relation. The Coopersmith Self-Esteem Inventories and Rotter's Internal-External Locus of Control Scale are used. Anticipated completion date: December 1996. Project Leader: Sandra Winter (408) 245-3609.

Ontario Ministry of Transportation
Safety Research Office
2nd Floor, West Building
1201 Wilson Ave.
Downsview, Ontario, M3M IJ8
Contact: Leo Tasca (416) 235-3623

Validation of the Senior Driver Research Inventory (SDRI). The SDRI was developed for the Ministry of Transportation of Ontario by Northport Associates. It currently consists of 62 self- reporting items which assess: (1) perception of functional deficits and the risks associated with them; (2) older driver willingness to acknowledge their functional deficits; and (3) compensatory tactics used by older drivers to minimize perceived risks and functional deficits.

Preliminary SDRI was pilot -tested. Three general scales (ability/risk, denial and compensation) were developed and subdivided into six sub-scales. Reliability coefficients calculated for each scale shows a moderate to high reliability. Scores on each SDRI sub-scale provide a measure of the subjects' ability to perceive functional deficits and associated driving risks, acknowledge their deficits and compensate for them.

SDRI scores of older drivers will be validated against their performance on the G2 road test, a valid and reliable road test developed as the advanced Level 2 exit test for Ontario's Graduated Licensing Program. Three hundred volunteers will complete the SDRI, a vision test and the G2 road test. Volunteers are aged 50 and above, and have at least 10 years driving experience but are not professional drivers. Anticipated completed date: December 1996. Principal Investigator: Jim Andersen, Engel, and Townsend (416) 235-3627.

1994 Exposure Survey. Trip patterns and crash exposure are examined for Ontario drivers. Data are collected year-round so that seasonal variations in driving patterns and risk can be identified. As part of the exposure survey, a three-day trip 109 was mailed to a random sample of 11,250 drivers aged 16 and above. The trip 109 requests information on the origin, destination, duration, length, purpose, and number of passengers. A small pilot test also was undertaken to evaluate an electronic vehicle device known as the Autologger. Recent developments in computer software and hardware have made it worthwhile to examine the feasibility of in-vehicle data collection. Anticipated completion date: Summer 1996. Contractor: Human Factors North.

Analysis of the Useful Field of View. This study aims to develop a diagnostic benchmark for UFOV scores by estimating the range of UFOVs found in health individuals aged 16-85. Subjects will be screened for ocular diseases and/or brain damage. Anticipated completion date: Summer 1996. Contractor: University of Toronto.

Medical Fitness and Crash Risk. This project has four objectives: (1) survey selected jurisdictions in North America and Europe and compare the organization, content and function of their medical review programs; (2) review program evaluation studies in these jurisdictions; (3) review landmark legal decisions or impending court challenges in these jurisdictions related to physician reporting requirements; and (4) review the literature on driving performance and medical fitness relating to monocular vision; restricted visual field disorders (e.g., hernianopia and quandrantopia); seizure disorders, diabetes; prescription drug side effects of narcotic analgesics, anxiolytics and antidepressants, sleep disorders; and organic brain damage due to head injury. Anticipated completion date; Summer 1996. Contractor: Human Factors North.

Crash Involvement and Injury Outcomes by Age and Gender. The Ontario Ministry of Transportation is developing a detailed statistical profile of all crash-involved drivers from 1992-1994. The study focuses on three older age categories: 60-69, 70-79 and 80 and above. Crash involvement frequencies and patterns for these age categories and patterns for these age categories are compared to each other and to drivers aged 16-19, 20-24, 25-44 and 45-59. Each age category is also subdivided by gender. Other key explanatory variables include pre-crash driver action, pre-crash vehicle maneuver, initial impact, location and environmental conditions. Dependent variables include crash frequencies, crash patterns and injury outcomes (injury/property damage only). Anticipated completion date. Summer 1996. Contractor: Ontario Ministry of Transportation.

Alberta Mental Health Research Fund
Alberta Heritage Fund for Medical Research
3125 Manulife Place
Edmonton, Alberta T5J 3S4
Contact: Lois Hammond (403) 423-5727

Driving and Dementia: Consequences of Evaluation and De-licensing. This study investigates the consequences that a driving evaluation and resulting recommendations about continued driving have for adults with dementia and their caregivers. Subjects include dementia patients who are participating in an ongoing research project that evaluates driving fitness and who have been referred to a driving evaluation by a physician. In cases where driving cessation is considered necessary, structured interviews are used to assess the psychosocial (e.g., psychological reaction, change in independence, social interactions) and financial impacts that the loss of driving privileges have for patients and caretakers. Patient reactions to the physician, the consequences for the patient-client relationship, the patient's compliance to the recommendation, and the role of the family in obtaining compliance are also addressed. For those who retained driving privileges, the emphasis is on documenting continued driving activities and reported difficulties, and changes in mobility and family relationships. The information obtained from the project will provide a basis for developing follow-up research and outreach programs.

Estimates indicate that 25-30% of dementia patients hold a valid driver's license and are currently driving at the time of diagnosis. Because dementia signifies a general loss of cognitive abilities, there is a question about the person's competence to drive. In the case of progressive dementias, such as Alzheimer's Disease, there will always be a point for which cessation of

driving is necessary. This study will help us better understand the impact this transition has on these patients and their caregivers. Principal Investigator: Allen Dobbs, University of Alberta (403) 474-8840.

APPENDIX B: TheAging Process and Physiological Functioning

I. Summary of Age-Related Deficits Relevant to Vehicle Operation

SENSORY FUNCTIONING

Vision

- reduced visual acuity at far distances
- less able to focus on near objects
- more likely to have cataracts, glaucoma, macular degeneration, especially after the age of 85
- require greater levels of illumination
- more sensitive to glare
- impairment of night vision
- peripheral visual field drops from 170 degrees in the young adult to 140 by age 50
- static visual acuity starts to decline slowly around age 50 and then more rapidly
- response to visual stimuli is slowed due to reduced acuity and sensitivity to contrast

Hearing

- less able to hear low and high frequency tones
- less able to differentiate between tones
- less able to block out background noise

COGNITIVE FUNCTIONING

Perception

- increased difficulty in ignoring irrelevant stimuli
- slower retrieval and processing of information
- spatial orientation and visual-motor integration abilities diminish with age

Memory and Learning

- after the age of 75, the learning rate diminishes to half that of a 20 year-old
- the age differences in learning ability until age 75 are small
- reduction in short-term memory

Attention

- ability to divide attention diminishes
- searching and scanning abilities, which require selective attention, diminish

Intelligence

- the level of general intellectual functioning is maintained into normal old age (lower scores on standard IQ tests)
- differences are more pronounced on tests of fluid intelligence, which measure ability to think and reason abstractly, than those of crystallized intelligence, which measure the ability to learn from experiences
- differences are more pronounced on tests of nonverbal abilities than those of verbal skills which are maintained until about age 70 and then decline only gradually
- the prevalence of significant cognitive impairment for non-institutionalized persons:

aged	65-74	3%
	75-84	14%
	over 85	20%

PSYCHOMOTOR and PHYSICAL FUNCTIONING

Reaction Time

- general psychomotor slowing most likely due to slower peripheral and central processing
- take longer to perform tasks
- reduced speed of motion inverse to the complexity of the movement required
- slightly slower simple reaction time
- the more complex the stimulus display and the decision to be made, the greater the difference in reaction time between the young and old
- the elderly often substitute accuracy and consistency for speed of response

Strength and work capacity

- reduced handgrip, shoulder and back strength
- reduced capacity for continued exertion
- limitations of motor activity
- work capacity of 70 year- old equal to half that of 20 year-old
- small but gradual decrease in muscle strength until age 60, then the decrements become more dramatic
- losses are greater in women, greater in the lower than the upper extremities and greater in fast versus slow velocity movements
- most loss of strength up to the age of 70 is due to disuse

OTHER PHYSIOLOGICAL AND AGE-RELATED CHANGES

Body Conformation and Composition

- diminution of stature
- posture less likely to be erect
- weight loss begins between 50 and 70, stabilizes in women
- brain weight declines
- heart weight does not decrease, and actually increases relative to total body weight
- overall decrease in bone mass starting in the 20s
- increase in fat deposition until age 50 then decreases thereafter
- increase in body mass even though weight stabilizes or decreases
- total body water decreases resulting in problems stabilizing body temperature

Tissues and Organ Systems

- elevation in blood pressure
- increased incidence of arthritis and rheumatism
- onset of osteoporosis and osteoarthritis
- reduction in muscle mass as great as 30 percent between 30 and 80 years of age
- the reduction in muscle mass accounts for much of the loss of strength

Respiratory and Cardiovascular Systems

- reserve resources available for coping with activity or challenge above that of the basal or resting state are globally reduced with aging
- functions at rest are adequate
- more likely to have chronic respiratory problems
- total lung capacity is reduced (however, when controlled for height, total lung capacity may be independent of age)
- more likely to have cardiovascular disease
- increase in atherosclerosis
- decline in maximal heart rate, maximal exercise capacity, increase in systolic blood pressure, left ventricle wall thickness, deterioration of glucose and lipid metabolism. Rate of loss of cardiac output is equal to 1 percent per year starting in the 30s

ADDITIONAL DISCUSSION

The Aging Process and Physiological Functioning

There are a number of specific age-related physiological changes that occur with normal aging. Vision, in terms of functionality, is one of the most important sensory modalities. Visual changes characteristic of the aging process include:

- lower visual acuity at far distances and less ability to focus on near objects, static visual acuity starts to decline slowly around age 50 and then more rapidly
- increased likelihood of cataracts, glaucoma, macular degeneration, especially after the age of 85
- impairment of night vision due to requirements for greater levels of illumination, increased sensitivity to glare and slower accommodation
- reduced peripheral visual field, (from 170 degrees in the young adult to 140 by age 50)

Another critical sensory modality is hearing. The aging process often results in:

- decreased ability to hear very low and very high frequency tones and to differentiate between tones
- decreased ability to block out background noise

Cognitive functioning including attention, memory, and learning is also negatively impacted by the aging process resulting in:

- increased difficulty in ignoring irrelevant stimuli
- slower retrieval and processing of information
- diminished spatial orientation and visual-motor integration
- diminished learning rates. After the age of 75 it is half that of a 20 year old (however reductions in learning ability until age 75 are small)
- reduction in ability to 'time share' or divide attention among two or more tasks
- diminution in searching and scanning abilities which require selective attention

Intelligence which is an index of cognitive functioning, shows some decrease with age. However, the decrease may have been overestimated in the past. This overestimation results from using a cross sectional methodology. This methodology involves comparing different individuals with different ages. A more appropriate methodology (longitudinal) involves gathering data for the same individuals as they age. The outcomes of longitudinal studies suggest that the level of general intellectual functioning is maintained well into old age. Use of longitudinal comparisons correct for educational opportunities and other experiential considerations. For example, as a group, individuals born in 1916 are likely to have had less education than a socio-economically similar individual born in 1966. Such artifacts appear to explain findings involving weaker scores on standard IQ tests.

However, there are age-related differences in measured intelligence. For example, differences were more pronounced on tests of fluid intelligence, which measure ability to think and reason abstractly, than those of crystallized intelligence, which measure the ability to learn from experience. Also, reductions in scores on tests of nonverbal abilities are larger than those of verbal skills. Verbal skills are maintained until about age 70 and decline only gradually. In general, the prevalence of significant cognitive impairment for non-institutionalized persons aged 65-74 is about 3 percent, by 75-84 it is 14 percent, and over 85 it is greater than 20 percent.

Psychomotor and physical functioning are critical factors in vehicle operation. One important area is reaction time. Aging results in a general psychomotor slowing, most likely due to slower

peripheral and central processing. Simple reaction time is only slightly slowed by the aging process, but it takes longer to perform more complex tasks. There is a reduction in the speed of motion which is inverse to the complexity of the movement required. The more complex the stimulus display and the decision to be made, the greater the difference in reaction time between the young and old. Older operators often compensate by substituting accuracy and consistency for speed of response.

There is a small but gradual decrease in muscle strength until age 60, then the decrements become more dramatic. The work capacity of a 70 year-old is equal to half that of a 20 year-old. Finally most loss of strength up to the age of 70 is due to disuse.

Strength and work capacity are diminished due to:

- reduced handgrip, shoulder and back strength
- reduced capacity for continued exertion
- limitations of motor activity
- The losses are greater in women, greater in the lower than the upper extremities, and greater in fast versus slow velocity movements.

There are a number of other age-related physical and physiological changes:

Body conformation and composition

- diminution of stature
- less erect posture
- overall decrease in bone mass starting in the 20s
- weight loss beginning between 50 and 70, (stabilizes in women)
- decline in brain weight
- heart weight increases relative to total body weight
- increase in fat deposition until age 50 then decreases thereafter
- increase in body mass even though weight stabilizes or decreases
- total body water decreases result in increased difficulty in stabilizing body temperature

Tissues and Organ Systems

- increase in blood pressure
- more likely to suffer arthritis and rheumatism
- onset of osteoporosis and osteoarthritis
- reduction in muscle mass as great as 30 percent between 30 and 80 years of age

Respiratory and Cardiovascular Systems

The reserve of function available for coping with activity or challenge above that of the basal or resting state is globally reduced with aging. However, functions at rest are usually adequate. Older adults are:

- more likely to have chronic respiratory problems
- more likely to have cardiovascular disease
- reduced cardiac output, the rate of loss is equal to 1 percent per year starting in the 30s

II. Discussion of Impairing Conditions

Dementias

Dementia is characterized by the loss of cognitive abilities such as memory, perception, verbal ability, and judgment. In most instances, losses are permanent and progressive resulting in total incapacitation and even death. Although there are more than 60 forms of dementia, Alzheimers' disease is the most prevalent, accounting for more than half of all cases of dementia. Estimates of the prevalence of Alzheimers' disease range from about 10 percent of all those over 65 years of age to almost 50 percent of those over 85 years of age. Other types of dementia include vascular dementias (such as multiple infarct dementia), Pick's disease, Parkinson's disease, Huntington's disease, progressive supranuclear palsy, AIDS, brain trauma, anoxia, and metabolic or toxic disorders.

Various studies have reported that 2.6 to 15.4 percent of those over 65 years of age suffer from some type of mild to moderate dementia. Severe dementia is characterized by gross functional loss and total dependency. Therefore, only those with mild to moderate dementia are likely to still be operating vehicles. Early symptoms of dementia include memory loss, disorientation and impaired judgment. Overlearned activities such as those used in driving may be spared, for a time, but responses requiring judgment, such as those presented by an obstacle or hazard, are typically impaired early in the progressive course of disease. Visual abilities impaired by dementia of the Alzheimer type including tracking performance, field deficits, and retinal degeneration causing impairment of contrast sensitivity, depth perception, motion and orientation.

Parkinson's and other subcortical dementias involve both mental and neuromuscular deficits. Mental deficits are usually mild to moderate in severity and include mental slowness, lack of initiative, forgetfulness, cognitive impairment and mood disturbance. Physical deficits include slowness of movement, rigidity, and tremor. Approximately 25 percent of those with Parkinson's disease will develop symptoms of dementia in addition to neuromuscular deficits. Pharmaceutical treatment may improve symptoms but merely postpone the incapacitating and progressive effects of the disease.

Vascular dementias are caused by multiple vessel occlusions which result in a lack of blood to a specific area of the brain and present with abrupt onset and stepwise rather than continuous deterioration. Symptoms include both those of cortical dementias, such as Alzheimer's, and subcortical dementias, such as Parkinson's. Vascular dementias are not treatable but the state of impairment can be stabilized if the underlying cause of occlusions is treated.

Pseudodementias such as depression can cause slowness of response, forgetfulness, disorientation, attention deficit, psychomotor slowing, and impaired effortful processing. Unlike true dementias, depression can be completely reversible. Pseudodementia may account for as much as 30 percent of dementia diagnoses.

Dementias affect ability to operate a vehicle in the critical functions of perception, selective attention, divided attention, judgment and impulse control. Unsafe driving in persons with dementia has been attributed to declines in attention and visuospatial skills. However, as many dementias are of gradual onset and progressive in nature the mere diagnosis of dementia is insufficient to determine the functional ability of the afflicted.

Cardiovascular Conditions

Cardiovascular conditions include coronary heart disease, angina pectoris, myocardial infarction, cardiac failure, cardiac arrhythmias, cardiac effects of pulmonary disease and hypertension. The primary aspects of cardiovascular disease that may impair ability to operate a vehicle include sudden loss of consciousness, and the symptoms of pain, dizziness and blurred vision brought on by myocardial infarction. Insufficient oxygen supply to the brain may cause impaired cognition in some heart conditions, and sudden death at the wheel may also occur.

The symptoms of congestive heart failure include weakness, fatigue, confusion, and impaired alertness and stamina. It has been estimated that approximately 30 percent of those over 65 have some form of cardiovascular disease. The risk of cardiac failure increases a hundredfold from 35 to 65 years of age. The incidence of heart failure for men aged 65-74 is 8.2 per 1,000 (four times the rate of those aged 45-54), rising to 13 per 1,000 for those 75-84 years of age, and 50 per 1,000 for those 85-94 years of age. An increased societal risk posed by those who drive with known cardiovascular disease cannot be determined from a review of the literature.

Cerebrovascular Conditions

Cerebrovascular accident (CVA) or stroke has a sudden onset and is caused by interrupted flow of blood to part of the brain, an aneurysm of the wall of a blood vessel, or rupture in the wall of a blood vessel. The likelihood of stroke increases with age and is about 1 percent per year for those aged 65-74. Resulting disabilities may include musculoskeletal impairments, sensory damage, perceptual and cognitive problems, and behavioral or emotional problems. The type of symptoms suffered depend on the part of the brain affected and the extent of damage. Transient ischemic attacks (TIAs) are by nature short-lived with supposedly no residual impairment but can result in temporary monocular blindness, weakness in one side of the body, language deficit, confusion and limited voluntary movement.

Residual deficits that have shown to significantly impair driving ability among CVA patients include problems in spatial perception, visual scanning and other visual problems, poor tracking ability, slowness of response, and confusion when situations require complex actions. These deficits result in an inability to perceive hazards, drifting sideways while driving, lack of caution, and inattentiveness to signs and traffic conditions. Although many CVA patients successfully compensate for deficits by restricting their driving or modifying their driving style, this requires an awareness of deficits and self-critical abilities which may be dysfunctional.

Diabetes Mellitus

The prevalence of Type II diabetes, Non-Insulin Dependent Diabetes Mellitus (NIDDM), a disturbance of glucose metabolism that can be controlled through the use of hypoglycemic agents and prescribed diet, increases after the age of 45, reaching approximately 8.8 percent of those aged 65-74. Ninety percent of the population with diabetes, and most elderly diabetics, have the NIDDM type which is characterized by the increased likelihood of comorbidities such as cardiovascular disease, cerebrovascular disease, diabetic neuropathy, cataracts and diabetic retinopathy. Poor diabetic control can result in slowed attention, fine motor skills and response time, fatigue, lethargy and sluggishness and studies have shown that older persons with NIDDM have impaired short-term memory. The bulk of the literature reflects some increased risk for drivers with diabetes due to the cognitive impairments caused by hypoglycemia, however, this increased risk appears to be independent of age. Diabetic neuropathy may prevent older diabetics from detecting symptoms of hypoglycemia leading to possible loss of consciousness, convulsions or coma.

Epilepsy

Epileptic seizures are characterized by a loss or altered state of consciousness. Symptoms range from dizziness or clouded thought processes to disorientation, confusion, bizarre behavior, and altered visual and auditory experiences to total loss of consciousness. The anticonvulsant medications that can control seizures can also adversely affect one's state of consciousness. Those with uncontrolled seizures do not qualify for an operator's license due to the high likelihood of recurrent seizures. However, approximately 70 percent of those with epilepsy achieve remission with proper treatment. The increased risk to older drivers with epilepsy appears to be not significantly different from other drivers over 25 years of age.

Ocular System Disease

Normal visual deficits and those attributable to subclinical pathology become difficult to delineate as individuals age. A dramatic decline in visual acuity that begins at age 60 or 70 can be attributed to cataracts, senile macular degeneration, diabetic retinopathy and glaucoma. It has been estimated that 19 percent of those aged 65 to 75, and 50 percent of those over 75 have at least one of these conditions. These conditions result in reduced contrast sensitivity and insensitivity to glare. Cataracts tend to reflect back light and scatter it reducing the light that reaches the retina and increasing glare. The prevalence rate of cataract and macular degeneration increases tenfold from under age 65 to over age 75, with over 40 percent of those over age 80 having cataracts. Glaucoma, which diminishes peripheral vision and can cause blindness affects 3 percent to 5 percent of those over 65 years of age and is twice as common in those over age 75 as those under age 65. Senile macular degeneration, in which the central area of the retina degenerates, affects 1 percent to 3 percent of those over 65 but is the leading cause of blindness in the elderly. The most successfully treated ocular diseases are cataracts which can be surgically curable. However, cataracts must progress to opacity before they can be removed therefore continuing to present a functional deficit until that point. Studies have shown that drivers with visual field loss due to glaucoma, retinal disorders and cataracts have an increased risk for motor vehicle accidents twice that of non-visually impaired drivers.

Chronic Obstructive Pulmonary Disease (COPD)

COPD is characterized by a decline in lung function caused by limited oxygenation of the blood and accounts for a decrease in the maximum aerobic work a person is capable of. Although air flow abnormalities begin around age 40, dyspnea does not become pronounced until between age 50 and 70. The common symptoms are weakness and fatigue requiring oxygen therapy to allow exertion, diminished judgment and concentration, cough syncope in severe cases, and pulmonary hypertension and ultimately heart failure. In one study, 13 percent of men and 4 percent of women had COPD.

Arthritis

There is a dramatic increase in the prevalence of osteoarthritis after the age of 50 reaching 50 percent of those over 65 years of age with arthritis in at least one joint. The activities of approximately five million older persons are limited because of arthritis. The presence of arthritis causes pain and restricts mobility, range of motion, and strength. Although arthritis-related disabilities are less severe than those of many other chronic conditions, when arthritis coexists with other chronic conditions, the disabilities are exacerbated. The absolute restriction of range of motion, decreased grip strength, decreased head and neck mobility, and hip and leg motion limitations can interfere with an arthritic's ability to safely operate a vehicle. The pain of arthritis also produces involuntary hesitation which can compromise safe operation of a vehicle. The psychology of immobility also can prevent a person with arthritis from relinquishing activities that may further restrict mobility such as driving.

Medications and Polypharmacy

Medication use increases with age. Studies suggest that at least three quarters of those over 65 use prescription medications and the Medicare population takes on average ten drugs a day. Polypharmacy refers to the situation in which multiple medications are taken, possibly with interacting effects. The combined influences of severe illness, comorbidities and multiple medications are more indicative of adverse reactions than age per se; however, the likelihood of these combined influences increases with age. The likelihood of adverse drug reactions dramatically increases with age as well, with an incidence among those aged 65 or older three to seven times that of young adults. Older people are more sensitive to medications than younger adults. Reduced hepatic and renal function and altered body composition diminish the capacity for medication excretion in older individuals.

Depressants such as benzodiazapines (prescribed for anxiety and insomnia), antipsychotic drugs (major tranquilizers) and antihistamines can impair cognitive and psychomotor functioning due to their sedating effect. Clinically significant drowsiness attributable to benzodiazapines appears to be two to three times more likely to occur in older adults than younger adults. Tricyclics prescribed for depression have been shown to decrease functioning in the older adult due to a sedating effect as well. Hypoglycemics taken for diabetes mellitus and opioid analgesics also have been shown to adversely affect cognitive and psychomotor functioning. Although not a large percentage of those over 65 abuse alcohol, they are particularly susceptible to interactions between medications and even small amounts of alcohol. Alcohol has a pronounced effect on

motor skills when taken in conjunction with psychotropic medications. Alcohol also increases the depressant effect of tricyclic antidepressants, benzodiazepines and antihistamines in the elderly. Although recommendations have been made for the elderly driver to avoid alcohol, narcotics, hypnotics, anxiolytics, barbiturates, analgesics, antipsychotics, antihypertensives, skeletal muscle relaxants, ophthalmic agents and antihistamines, this is highly problematic considering the high necessity for and prevalence of these medications and the lack of epidemiological confirmation that specific medications increase risk.

III. Selected Excerpts from Draft White Paper for Medical Research and Practices Expert Panel, March 21-22, 1996

(For discussion purposes only, do not cite or quote)

A. Introduction

On December 4, 1995, Secretary Peña instructed:

"The DOT should be constantly proactive regarding emerging safety and service problems in the Nation's transportation system. One problem demanding such attention is the ongoing demographic shift in the age of those who operate in our system...We need to investigate the special needs of these operators and develop responses...

By anticipating emerging service and accessibility problems in the nation's transportation system, DOT's strategic planning will develop comprehensive, cross-modal strategies to stay ahead of societal changes and to build accommodation into the system.

Increased longevity and the maturing of the "baby boom bulge" are likely to raise two transportation issues:

- An increasingly large cohort of older people accustomed to mobility and/or recreation in self operated vehicles

- Many experienced commercial transportation operators available to continue employment longer

DOT needs to obtain information about aging vehicle operators, both commercial and noncommercial. This information can be used to develop strategies to help experienced commercial operators to maintain their proficiency and independence further into maturity, to safely extend the mobility of aging Americans as private operators and to ensure continued mobility and accessibility for aging vehicle operators.

DOT has initiated Improving Transportation in a Maturing Society (ITMS) to determine the impact that postponed retirements, longer productive lives and the growing segment of older operators will have on the Nation's transportation system. While ITMS expresses an encompassing issue, for the purposes of addressing it, ITMS has five components:

Aging Scenarios
Medical Research and Practices
Management Practices
Human Factors and Technology
Alternatives for Meeting Personalized Mobility Needs

The main source of information for this departmental initiative will come from the results of the invitation-only Expert Panels, each of which is addressing one of five components cited. When compiled, the DOT will use the results of these panels to define how best to maintain the proficiency of and to accommodate the anticipated increasing numbers of older operators.

Participants in the second of this series of Expert Panels, Medical Research and Practices, to be held in Chicago on March 21-22, 1996, will discuss and report on the medical aspects of the aging operator in each mode of transportation, including those specific to commercial and private operators. This White Paper puts forward the background issues for this Medical Research and Practices Expert Panel. Section II provides the context in which the pertinent medical issues will be discussed. Section III discusses the age-related physiological changes that occur with normal aging. Section IV lists the current medical requirements for both commercial and recreational operators. Section V summarizes the medical conditions that could potentially impair the aging vehicle operator. Section VI discusses evaluation and assessment of medical conditions in older operators. Section VII discusses medical interventions for the older operator. Finally, Section VIII discusses the role of the medical community vis-a-vis the older operator.

B. Issues Related to Age and the Ability to Operate Vehicles and Enjoy Transportation Services

Because DOT is responsible for ensuring safety in transportation and meeting the need for mobility in a population with an increasingly greater propensity for mobility, Secretary Peña has noted:

> *" there is an ongoing demographic shift in the age of those who operate our transportation system. The aging work force of aircrews, commercial vehicle operators, rail crews and mariners are likely to seek to work longer and to postpone retirement. Similarly there will be increasing numbers of aging private motorists and recreational boaters and pilots. We need to investigate the special needs of these operators..."*

The issues of aging vehicle operators concerns the DOT at this time for many reasons including; the increased number of people over age 65 and the growing relative proportion of people in these age categories, the movement to postpone retirement due to the economics of retirement, advances in health care and changes in life styles with the movement to the suburbs.

Transportation involves people as both operators or passengers. Regulation and custom have defined the point at which people are sufficiently mature to operate the various transportation modes by means of licensing and certification procedures. As transportation technologies have developed, the definitions of maturity required for operation have been refined. However, as the number of operators in the older segment of the population has expanded, questions have arisen

whether these older workers retain the requisite abilities to operate the transportation systems safely. Further, U.S. society relies to a very large extent on personal transportation, particularly the automobile. Age related restrictions in the ability to operate personal vehicles due to reduced capacities isolates large segments of our population from participating in society.

Older people are both producers and consumers of transportation. Obviously, such activity is socially and economically beneficial. Mobility and productive work are to be encouraged. However, there is a sense that aging somehow can interfere. There is a need for consensus on what aging means in terms of ability to operate commercial and private transportation vehicles and to enjoy the benefits of various transportation modes, including walking.

While age refers to the length of time during which a person has lived and the periods or stages of life, there is a specific chronology which defines when people are recognized as mature and attain specific legal rights and responsibilities.

Few such chronologies have been established for relinquishing rights and responsibilities for the older segment of the population. While all people will show the effects of aging or undergo change and a diminution of essential qualities with the passage of time, there are large individual difference in the effects and impacts of the aging process. The problem is how to recognize and deal with these differences while maintaining both safety and social mobility.

In a gerontological sense, 'age' connotes a host of physical, psychological, cognitive, and socioeconomic changes. Sensory functions, perceptual processes, decision making, and psychomotor performance decline, sometimes, predictably. Yet the decline is not constant for any one individual. In fact, differences among individuals widen as age increases. This makes analysis and policy making on aging difficult. Even if age changes were precisely identified, the impact on transportation would not always be clear. Humans compensate for deficits, finding alternative ways to do activities.

C. The Age-Related Physiological Changes that Occur with Normal Aging

General Considerations

- Aging is universal and inevitable but not necessarily predictable
- As the human animal ages, homeostasis becomes more difficult to maintain as resistance to environmental stress declines
- Aging is characterized by a decreased ability to function within one's environment
- Aging-related changes are characteristically detrimental in nature, linear with time, and lack sharply defined points of transition
- There are wide individual and socio-cultural variations to the aging process
- Normal aging changes are general to individuals, not produced by disease, and come about purely through the passage of time
- Changes begin at different chronological ages and progress at varying rates

Aging vs. Disease

The universal consequence of the aging process on the human body is the decreased efficiency and ability of the body under increased demand to maintain functional levels within normal limits and the slowed rate of return to normal levels once systems are stressed. Conduction velocity of nerves, cardiac output, renal function and respiratory function are all less capable of withstanding stress in older individuals.

The normal process of aging is associated with increased incidence and severity of diseases. This increased and often multiple pathology co-occurs with reduced homeostatic sufficiency. Aging, therefore, becomes the succession of events that accumulate and increase the probability and onset of functional failure and disease. Differentiating between disease processes and those gradual degenerative changes that develop over the passage of time is often difficult if not impossible. Additionally, as the prevalence of chronic disease increases with age, it becomes more difficult to differentiate between functional loss due to the effects of disease versus that concomitant with the aging process.

The Heterogeneity of the Aging Process

The aging process involves complex interactions of genetic and environmental influences. Therefore, there exists a lack of uniformity of age-related changes between individuals and within the same individual. The onset, rate and degree of changes vary depending on the organ, system, or function in question.

It is important to consider the compensatory responses that can counteract losses due to the normal process of aging and the potential for rehabilitation to make up for functional losses. Also, the heterogeneity between individuals increases with age, both in terms of decrements and compensatory ability. While a single impairment might be compensated for with relative ease, multiple impairments are more difficult to overcome. This extreme heterogeneity of functional status strongly supports the view that the elderly be evaluated on an individual basis, especially as health and fitness status, and social, economic and environmental conditions continue to impact how Americans age.

The Aging Process and Physiological Functioning

Older people, on average, do not perform as well as younger adults on almost all available measures of physiological functioning. However, in many cases, these deficiencies are small and the range of measured responses often overlap, with some older individuals functioning better than their younger counterparts. Therefore, these average measures can not predict individual performance. Certain generalities can be made however regarding the physiology and functioning of older persons in comparison to younger adults.

SENSORY FUNCTIONING ..... (See Appendix B-I, above)
PSYCHOMOTOR and PHYSICAL FUNCTIONING ..... (See Appendix B-I, above)
OTHER PHYSIOLOGICAL AND AGE-RELATED CHANGES .... (See Appendix B-I, above)

D. DISEASES OF THE ELDERLY

Limited to Aging
Osteoporosis
Osteoarthritis
Prostatic Adenocarcinoma
Polymyaglia rheumatica
Temporal arteritis

Associated with Aging
Myocardial infarction
cerebrovascular disease
nephritis
cirrhosis
pneumonia
septicemia
NIDDM
Neoplasm
Hypertension
Alzheimer's disease
Parkinson's disease
Emphysema

E. MEDICAL CONDITIONS THAT MAY INCREASE DRIVING RISK

Age-Related Physiologic Changes	Disease and Disorders Common in Older Persons
Decreased vision	Cardiovascular and pulmonary diseases
Decrease static visual acuity	Ischemic heart disease
Decrease dynamic visual acuity	Arrythmias
Decreased temporal fields	Sleep apnea
Decreased resistance to glare	Chronic lung disease with hypoxia
Decreased low luminescence vision	Diabetes mellitus
Decreased reaction time	Neurologic diseases
Hearing loss	Alzheimer's disease and cognitive impairment
	Parkinson's disease
	Stoke
	Neuropathies
	Seizures
	Polypharmacy
	Arthritis
	Alcohol Use

Adapted from Reuben, DB (1993). Assessment of Older Drivers. *Clinics in Geriatric Medicine*, 9(2), pp 449-459.

Percentage of Persons Aged 65 and Older with Functional Impairments

Function	Men(%)	Women(%)
Visual impairment	8.60	6.38
Color blindness	2.38	non-estimable
Cataracts	9.80	19.38
Glaucoma	5.37	4.91
Hearing impairment	39.55	26.91
Tinnitus	9.81	8.79
Mobility impairment	4.23	8.52
Self-care limitation	6.94	8.07

Colsher, PL and Wallace RB (1993). Geriatric Assessment and Driving Functioning. *Clinics in Geriatric Medicine*, 9(2), pp. 365-375.

Skills Needed for Driving Capably

Sensory Function
- Vision
  - Static visual acuity
  - Peripheral vision
  - Depth perception
  - Color vision
  - Dynamic visual acuity
  - Night vision
  - Glare recovery
  - Ability to change focus from near to far
  - Entire visual field
- Hearing

Cognitive Functioning
- Memory
- Attention
- Visuospatial skills such as systematic scanning of environment, judging distances and speeds, locating and using controls appropriately
- Verbal and information processing
- Decision making and problem solving

Psychomotor Functioning
- Muscle strength
- Range of motion
- Grip strength
- Reaction time

Colsher, PL and Wallace RB (1993). Geriatric Assessment and Driving Functioning. *Clinics in Geriatric Medicine*, 9(2), pp. 365-375.

Characteristics Related to Age and Driving Ability

Sensory
- Static Visual Acuity
- Dynamic Visual Acuity
- Low Illumination Acuity
- Low Contract Acuity
- Contrast Sensitivity
- Dark Focus Accommodation
- Glare Resistance
- Glare Recovery
- Visual Field
- Color Vision
- Hearing

Attentional
- General Attention Level
- Attention Switching
- Attention Sharing
- Selective Attention

Perceptual
- Form Identification
- Form Recognition
- Field Dependence
- Visual Search Effectiveness

Cognitive
- Information Processing Rate
  - Short Term Memory
- Long Term Memory
- Decision making-time-distance judgment

Psychomotor
- Simple Reaction Time
  - Choice Reaction Time
- Tracking

Consciousness
- Level of Arousal

Physical
- Coordination
- Range of Motion
- Strength of Motion
- Smoothness of Motion

F. Issues for the Medical Research and Practices Panel to consider:

1. What affect does the normal aging process have on the physical and psychological functioning of individuals?

2. Specifically, what deficits can be expected in relation to the young adult?

   Sensory
   Psychomotor
   Cognitive
   Other

3. How does the aging process affect an individual's ability to operate a vehicle safely?

   Sensory
   Psychomotor
   Cognitive
   Other

4. What compensatory responses do older people employ to make up for the expected losses due to aging?

5. Are future cohorts of Americans expected to age differently than those who are elderly today?

6. How will these differences affect the safe operation of transportation systems?

7. What are the current medical requirements for commercial operators in the different modes of transportation?

8. What are the medical requirements for private or recreational operators (pilots, boaters, automobile drivers)?

9. What are the reporting requirements for medical professionals regarding the impairments of their patients that might pose a threat to themselves or the public?

10. What diseases are limited to the aging?

11. What diseases are associated with aging?

12. What impact does the presence of certain diseases or conditions have on the normal aging process?

13. What impact does the presence of certain diseases or conditions have on the ability of an older individual to operate a vehicle safely?

14. Has a relationship been made between the presence of certain diseases or conditions and the accident rate of various types of vehicle operators?

15. Does the presence of diseases or conditions affect operators of various types of vehicles differently?

16. Would the risk posed to the operator or the public by a certain disease or condition vary based on the type of vehicle?

17. Does the presence of certain diseases or conditions impact the older operator differently than the younger operator?

18. What evaluation and assessment techniques are appropriate to measure the impact of the aging process on an individual's ability to safely operate a vehicle?

19. Should the utilization of evaluation and assessment techniques vary depending on the presence of certain diseases or conditions?

20. What evaluation and assessment techniques are currently utilized to assess the ability of older vehicle operators?

21. What, if any, restrictions should be placed on vehicle operation based on the results of evaluation and/or assessment?

22. What medical interventions may ameliorate or lessen the impact of certain disease or medical conditions on the older operator?

23. What medical interventions are effective in assisting the older operator with limiting disease or medical conditions to function safely?

24. What role does the medical community have in transportation issues?

25. What role does the medical community have in evaluating the ability of older persons to operate vehicles?

26. What role does the medical community have in assisting older operators to maintain their mobility through the transportation system?

27. What role does the medical community have in reporting individuals who may pose a threat to themselves or the public due to impaired ability to operate a vehicle safely?

28. What requirements should be in force for the medical community regarding the reporting or monitoring of potentially unsafe vehicle operators?

Appendix C: Miscellaneous

I. Proposed Human Factors Handbook

The FHWA Human Factors Team is recommending the development of a *Strategy to Market* the highway safety applications and findings derived from the *Improved Highway Travel for an Aging Population* High Priority Area of research. This program is in its middle stages and results from a number of studies are becoming available that will soon be compiled in the *"Preliminary Human Factors Older Driver and Highway Safety Handbook."* Based on these guidelines, the FHWA Human Factors Team will develop a set of highway design applications geared to improve the driving performance of older drivers. A blueprint of these applications will be presented to communities for implementation with the goal of demonstrating their effectiveness through an increase in older driver safety and mobility. Long-term objectives include the implementation of these applications to a greater number of communities as their success is documented.

It has been determined that many of the emerging ITS innovations will present opportunities for increased mobility and safety for older operators. Concurrently, these same systems can also raise potential safety hazards or barriers to transportation. To address older operator and ITS issues, the Intelligent Transportation Society of America's S&HF Committee has recently initiated a new Subcommittee on Older Drivers and ITS. The FHWA is currently addressing older operator and ITS issues, and as a member of the S&HF Committee, FHWA has agreed to actively support this new subcommittee. This will be in addition to FHWA's current support of TRB Committee A3B13, Safe Mobility for Older Persons.

II. Aging Scenarios Data Needs

During the course of this strategic planning work it has become obvious that there is not a clear understanding of what the future holds for the aging baby-boom population. These individuals have grown up with a greater dependence on the automobile with 2+ car families being the rule than the exception. More women in this generation will have driven more extensively with more responsibility for the purchase and maintenance of their vehicle than has been true in prior generations. There may also be a tendency for this population to live further away from their place of employment, extended family members and goods and services. If people continue to retire in place this group may find themselves with greater mobility limitations once they stop or reduce their driving. However, most of the above is conjecture since there is no real data.

What is needed are longitudinal studies that follow an array of these cohorts over a long period of time (25-35+ years) to determine how they actually go about maintaining their mobility. The safety and mobility consequences of the aging process on this cohort group can only be understood through the conduct of such studies. These studies, if conducted on their own, can be quite expensive, but, if done in coordination with and as add ons to existing longitudinal studies, can be much less expensive. Fortunately, the federal government has realized the need for coordination in this area and has established a Forum on Aging Related Statistics that has

attempted to provide a source to permit collecting coordinated data for multiple applications. In this particular issue area surveys such as the health and retirement survey asks some transportation questions which could be extended in later surveys to develop a longer term perspective. Information is needed on employment/volunteer activities, retirement, patterns, fiscal patterns, living arrangements, transportation arrangements, (particularly after driving), health practices and driving capabilities, etc. This data should be collected in coordination with other on-going or proposed long term studies. Data from these studies should also be useful in the design and evaluation of systems to identify, assess, rehabilitate and regulate those drivers who have functional limitations that may limit their safe driving or use of other transportation systems.

III. Need to Improve Our Understanding of the Relationship Between Age, Medical Conditions, Functional Disabilities and Operator Performance

We have great difficulty in relating age-related changes in physiology and performance to the ability of the operator to maintain the required margin of safety while operating in the transportation system. While the FAA has established medical standards for pilots, this is less true for other modes. To date, we have little evidence of how the normal aging process or the interaction of age and disease interfere with an individual's ability to safely operate in the various transportation settings. There was general agreement concerning a need for additional research to develop an improved understanding of the relationship between the aging process and the performance of vehicle operators. This is especially true given the observation that people age at different rates and different body systems in the same person age at different rates.

Further, different predictors may be needed for males and females, as is documented in a review of empirical findings on measuring human functional aging by Anestey, Lord and Smith (1996) in *Experimental Aging Research*. "The results obtained by collating the correlations of biomarkers with age suggest that males and females should not be included as one group in functional age research; and where normative data is provided, this should be separate for males and females." (pg.261). Thus, there may be a need for gender specific norms relative to the aging process.

Stated in another way, it is clear that current information on the role of medical conditions and functional ability on crash involvement and operator performance is insufficient, and we can not develop clear guidelines on who should or should not drive. Also, evidence on the role of medications and safe driving is insufficient to enable physicians to prescribe the most cost effective safe medications. Therefore:

A.) There is need to continue to conduct epidemiological research on the relationship between and among medical conditions and functional disabilities and crash involvement and driving practices. Current knowledge does not permit clear guidelines because risk ratios for various conditions are either contradictory, too low or not actually appraised. There is an interaction between crash involvement and driving cessation that makes it difficult to provide clear guidance to physicians or to their patients.

B.) There is a need to determine how performance of operator tasks are related to medical conditions and functional disabilities. In addition to crash risk ratios the actual driving behavior of individuals with functional disabilities needs to be better understood. There are those who believe that the strategic and tactical decision that an individual makes are more important than their operating skills. There is a need to conduct research into these decision processes.

C.) There is a longstanding concern that medications may impair driving. Persons 65+ received 29 percent of all prescriptions and more than 80 percent receive one or more medications. There is a need for a better understanding of the role of medications. Physicians can often make therapeutic choices that reduce or eliminate exposure to specific medications that adversely effect driving. What is needed is information on what the adverse effects of commonly used medications, most notably, tricyclic antidepressants, benziodiazepine, and opioid analgesics.

IV. Developing New Driver-Aiding Technologies

The development of new technologies for aiding drivers and other operators may have been stifled by legal considerations. The legal problems are not related to the potential failure of the aid or device to function properly. They appear to result from the fact that an aid can allow an individual to operate a vehicle who would ordinarily be unable to do so.

The extension of liability beyond product quality seems to preclude major manufactures from developing and deploying innovations which could extend mobility to elderly operators. As an example the developers of driving aids used by handicapped operators appear to be almost entirely small after-market firms who produce custom products. These firms lack the research and development resources which may be required to advance these technologies. Further, because they engage in custom aftermarket work they have great difficulty in providing a truly integrated product. Their participation in theses markets may be possible only because they lack the resources to make them attractive targets for legal actions. The department should determine if innovation in this area is being hampered due to such liability exposure. If so it could examine legal innovations and remedies such as “Vaccine Pool” legislation.

Current advances in data acquisition and recording technology permit the use of in situ evaluation systems. An analogy is the increased use of Holter monitor technology to diagnosis medical conditions. This procedure connects miniature portable sensors and recorders to the patient for a period of time. The data collected permits evaluations of the patient as she or he goes about their normal life. For the evaluation of elderly operators, a portable recording system could be placed in his or her vehicle. This system would record visual, positional, temporal, and other data about the driver’s interaction with his or her normal driving environment. This data could be used both to evaluate driving skills and to identify areas for remediation. This new research area could provide an important tool for extending mobility safely.

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